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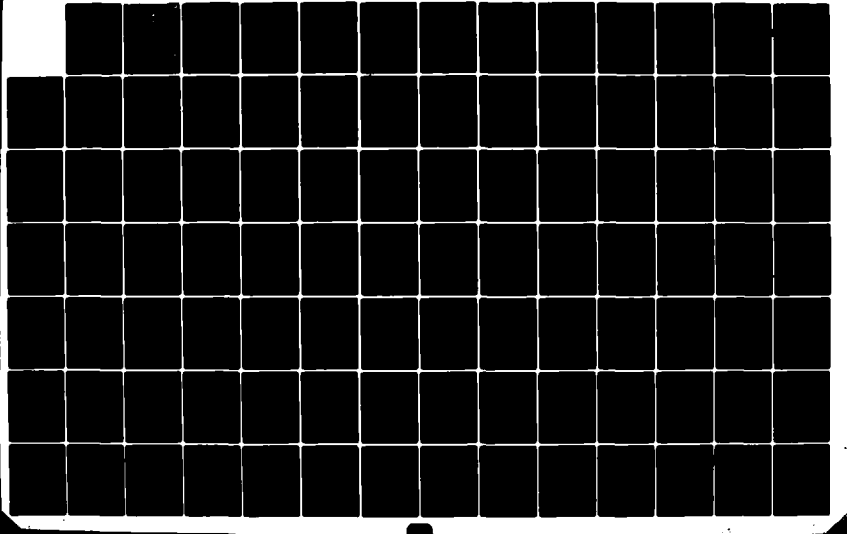

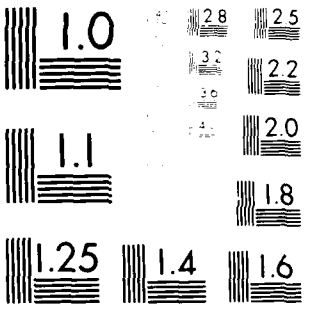

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TECHNOLOGY MODERNIZATION FOR DOD SUBCONTRACTORS: A STUDY OF MARKET, BUSINESS, FINANCIAL, AND CAPITAL INVESTMENT FACTORS

Richard P. Heffner, Captain, USAF
John A. Weimer, Major, USAF

LSSR 60-83

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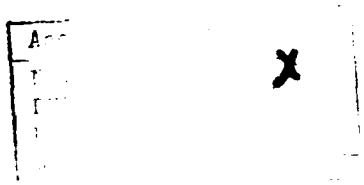

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The defense industry suffers from low productivity, old plants and equipment, and low capital investments by defense contractors. Technology Modernization (Tech Mod) is one approach taken by the DOD to improve productivity through incentivizing defense contractors to invest capital in modern plants and equipment. This study was designed to investigate Tech Mod capital investment decision making at the subcontractor level. First, twenty F-16 first-tier subcontractors were randomly selected and interviewed to determine if the subcontractors participating in the F-16 Tech Mod program could be differentiated from the subcontractors who had declined to participate on the basis of certain market, business, and financial characteristics. Second, the twenty subcontractors' ranking of fourteen capital investment factors indicated those factors considered "most significant" towards positively influencing capital investment for modern plants and equipment. The most significant capital investment factors served as the basis for the researchers' recommendations for investment incentives that the DOD should offer to subcontractors to motivate increased Tech Mod involvement and to enhance productivity throughout the subcontractor level of the defense industry.

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A Thesis

Presented to the Faculty of the School of Systems and Logistics

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In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Logistics Management

By

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CHAPTER I

THE RESEARCH PROBLEM

Introduction

During the last ten years, the health of the United States industrial base has received increased attention from senior government and military leaders. Of particular interest are the problems of low productivity, old plants and equipment, and low levels of capital investment within the defense industry. These defense industry problems are major contributors to rapidly increasing weapon system procurement cost and longer acquisition lead times. The Reagan administration has responded to the defense industry's condition by increasing the key investment accounts--procurement and research, development, test and evaluation--by more than $25 billion during 1981 and 1982 (18:53). The increases add to an already growing defense budget which is experiencing increased scrutiny from Congress and the general public.

In 1980, the Defense Industrial Base Panel of the Committee on Armed Services found that the general condition of the defense industrial base had deteriorated and was in danger of further deterioration (24:1). Two of the panel's specific findings were:

-productivity growth rates for the manufacturing sector of the U.S. economy are the lowest among all free world industrialized nations; the productivity growth rate of the defense sector is lower than the overall manufacturing sector; and

-the means for capital investment in new technology, facilities and machinery have been constrained by inflation, unfavorable tax policies, and management priorities [24:11].

These conclusions were reached after hearing testimony from thirty-four witnesses representing prime and subcontractors, associations, the military, and agencies and departments of the U.S. Government. From the testimony

> . . . a shocking picture emerged: the picture of an industrial base crippled by declining productivity growth, aging facilities and machinery, shortages in critical materials, increasing lead times, skilled labor shortages, inflexible government contracting procedures, inadequate defense budgets and burdensome government regulations and paperwork [24:5-6].

The relatively low level of investment in plant and equipment modernization is one of the most striking features of the current U.S. defense industry (6:58). During the 1970s, the United States aerospace industry invested only 2 percent of sales in new capital, while the average rate of investment for all U.S. industry was approximately 8 percent, and the average rate for all U.S. manufacturing was 4 percent of sales (24:17). The lack of investment has resulted in: 60 percent of the metal working equipment used on defense contracts being over twenty years old, the technology base in the industry declining by approximately 50 percent, and the cost per aircraft increasing by roughly 10,000 percent over the past thirty-five years (24:17; 22:4).

In the words of General Slay, "commitment must exist at all levels of government, the military, business and technology [24:6]," if the problems that threaten the future of the defense industry are to be solved.

As future weapon procurements require new technologies to meet a more sophisticated threat and more efficient manufacturing to meet tighter fiscal constraints, the past lack of investment in plant modernization and new equipment will have to be remedied. As part of the military attempt to improve industrial productivity, the Aeronautical Systems Division (ASD) of the Air Force Systems Command (AFSC) has selected two fundamental concepts as the foundation for its productivity enhancement efforts--contracting for productivity and technology modernization (Tech Mod) of contractor facilities (2:i).

The ASD view is that Tech Mod offers an alternative to piecemeal productivity improvement by systematically performing a top-down factory analysis of defense contractor's facilities (2:21). Overall, the Tech Mod program focuses on capital investment and technology through an equitable business deal centered on cost and risk sharing by the DOD and industry to improve contractor productivity (2:Appendix C). Specifically, the ASD Tech Mod program provides for increased return on investment, reduced acquisition costs, and reduced lead times by incorporating the factors that many studies have indicated are most significant to

building a strong industrial base--investment in modern plant and equipment and the timely application of new technology in manufacturing (2:21,Appendix C). Tech Mod's final objective is the reversal of declining productivity and capital investment in the defense industry. A critical part of the overall Tech Mod program is the special emphasis placed on Tech Mod at the subcontractor and vendor levels within the defense industry (2:23).

Initial applications of Tech Mod were confined mainly to the larger prime contractors, since this rather small group held a very high percentage of Air Force business and was expected to continue to do so in the future (2:6). Today, Tech Mod is being actively pursued at both the prime contractor and subcontractor levels. Subcontractor Tech Mod offers ". . . an excellent opportunity to affect a very large portion of the industrial base [2:113]." Subcontractors account for a substantial portion of a weapon system's cost. For example, over 60 percent of the costs of the F-16 and B-1B are generated by subcontractors. Additionally, it is through the subcontractors that a "multi-service link" can be formed (2:102).

Problem Statement

The Congressional Defense Industrial Base Panel identified the subcontractor level as having serious deficiencies. The ASD Tech Mod Program has placed special

emphasis on the "vital subcontractor network" which forms the foundation of the defense industrial base. However, no uniform DOD policies or contracting procedures exist that specifically identify the means to incentivize subcontractors to participate in Tech Mod. Consequently, the Air Force and the DOD must rely primarily on nonstandard, individual programs negotiated with defense subcontractors who are willing to invest in the modernization of their plant, equipment, and technology, and who are willing to share the benefits of improved productivity on defense work with the government.

Research Objectives

The first objective of the research was to identify characteristics of the first-tier subcontractors that were candidates for participation in the General Dynamics F-16 Industrial Technology Modernization Program. The second objective was to develop a set of investment incentives that should be offered to defense subcontractors as part of a comprehensive DOD Tech Mod effort to improve productivity throughout the subcontractor level of the defense industry.

Background

Defense Industry Structure

Individual firms comprising the U.S. defense industrial base can be classified as either prime contractors or subcontractors based on the contractual arrangements of

a particular program. A prime contractor has a direct contract with the government agency responsible for management of the program. First-tier subcontractors are under direct contract with at least one of the program prime contractors, second-tier subcontractors have a direct contract with a first-tier subcontractor, and so on. The number of existing subcontractor tiers is an area of uncertainty among experts, and each expert will at some arbitrary point combine all remaining subcontractors into a group and, depending on personal preference, refer to them as vendors or suppliers.

Confusion concerning a contractor's level can arise when a firm contracts among different programs (see Figure 1).

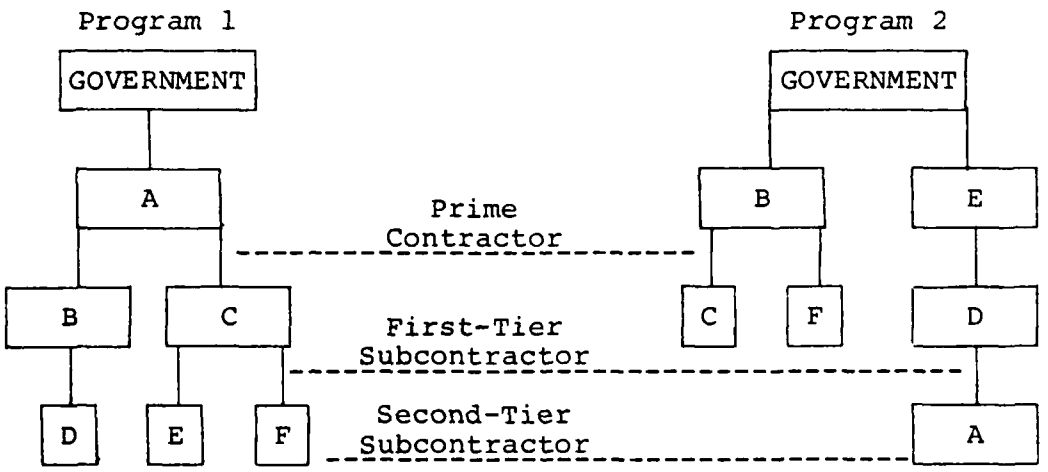


Fig. 1. Program Prime, Subcontractor Levels and Interrelationships

In Program 1, firm A is the single prime contractor; B and C are first-tier subcontractors; and D, E, and F are all second-tier subcontractors. Program 2 illustrates how contractors may change levels among programs. In Program 2, B and E are both prime contractors; C, F, and D are first-tier subcontractors; and A has moved from prime contractor (Program 1) to a second-tier subcontractor (Program 2).

The problems that are symptomatic of the declining trend in the overall economy are particularly evident in the defense industry (6:5; 24:10). Gansler identifies the high concentration of business among a few large firms as one of the major problems within the defense industry (6:11). This problem has evolved as a result of the highly sophisticated nature of modern weapon systems and the accompanying high capital requirements of research, development, and production (6:11). The few companies capable of doing business at the prime contractor level use a great deal of aging government-supplied plants and equipment, are required to maintain excess capability for DOD surge requirements, and have achieved a significant amount of vertical integration (6:5). Additionally, the inefficiency of government-prime contractor business, the reduced flow-down of "benefits" to the subcontractor level, and the diverse defense market structure has caused varying degrees of impact on defense contractors.

The above problems are magnified at the subcontractor levels because of the highly competitive subcontractor environment (3:35). In general, not only do subcontractors experience problems with capital formation and achievement of sufficient returns on investment, but the subcontractors' problems are magnified by the instabilities of defense programs (24:13).

Examining the plight of the defense industry, the Congressional Defense Industrial Base Panel clearly identified as one of the significant causes of its deterioration declining capital investment in new technology, facilities, and machinery. The panel also listed productivity as one of the most significant indicators of industrial health, while citing the absence of productivity growth in the declining U.S. defense industry (24:11,16).

Industrial Productivity

Productivity is a measure of output (goods and services) produced per unit of input (labor and capital invested). Figure 2 illustrates the severity of the decline that the U.S. industrial sector has experienced in productivity growth.

Since the late 1960s, a decreasing productivity growth rate has prevailed in the U.S. manufacturing sector (3:3). Testimony presented before the Congressional Defense Industrial Base Panel reinforced policy makers'

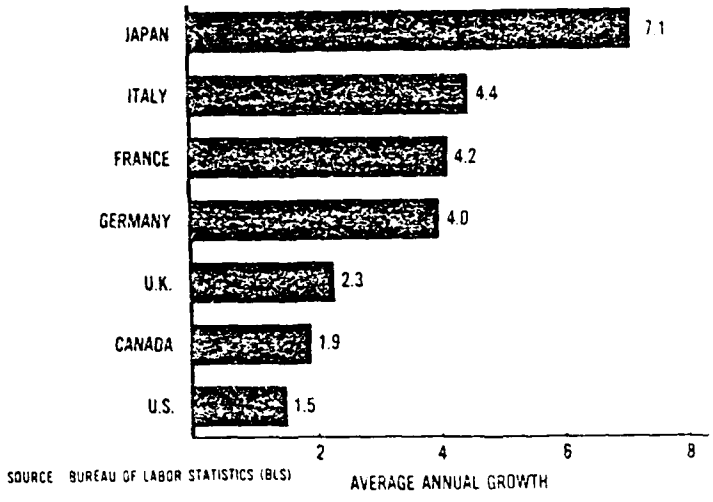


Fig. 2. International Productivity Growth 1960-1979 Total Economy [3:3]

concerns over the U.S. position among major industrialized nations: "The U.S. is dead last in productivity improvement among all industrial nations of the world [24:6]." This does not imply that U.S. industry in general or particularly the defense industry is ineffective. However, U.S. industrial efficiency is decreasing because the investments in plant modernization of the fifties and sixties are not being enhanced with new capital investments in the eighties (24:17).

Two offsprings of the defense industry's low rate of productivity growth are reduced surge capabilities and increased lead times. According to William J. Perry, Under Secretary of Defense for Research and Engineering,

> . . . if we wanted to double the production rate of F-16's in three months or six months, there is no way we can do it. I define that as a surge capability, and we don't have it [24:12].

Testimony by General Slay concurred with Dr. Perry's assessment of current surge capabilities. General Slay stated:

> . . . after nearly 18 months under surge conditions, we could only expect to get an aggregate of 22 more A-10's and no additional F-15's and F-16's than already exist on the currently contracted delivery schedule [24:12].

Lead times associated with military programs "increased dramatically" from 1977 to 1980 (24:13). For example, delivery time for aluminum forgings increased from 20 to 120 weeks, aircraft landing gear delivery time grew from 52 to 120 weeks, and integrated circuits that were available in 25 weeks now take in excess of 65 weeks for delivery. The increased lead times are the result of bottlenecks created by an industrial base which has not expanded to accommodate the increasing demand (24:13).

Increases in productivity can be achieved through a number of different strategies. Figure 3 illustrates how the National Council on Productivity (NCOP) and the Department of Commerce (DOC) view the main components of productivity and their relative contributions toward increasing productivity.

Numerous national studies, the NCOP, and the DOC have indicated that over 80 percent of productivity

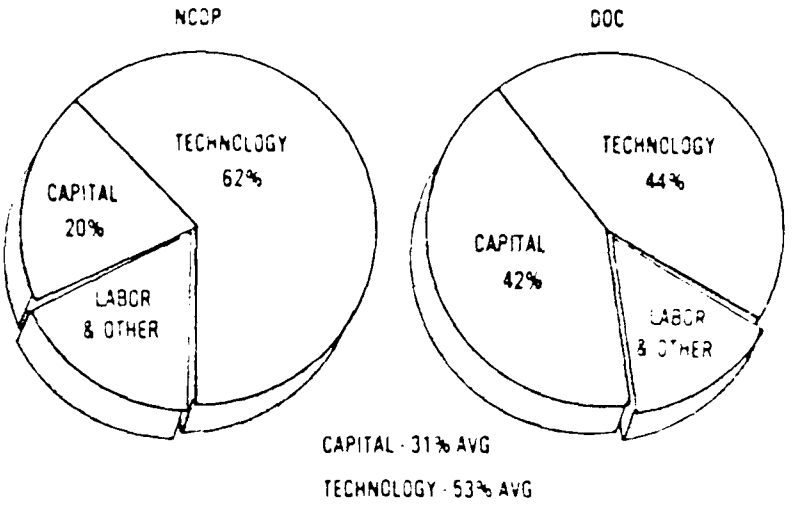


Fig. 3. Contributions to Productivity Increases [14:2]

increases are attributable to a combination of technology and capital (14:2).

The capital investment by U.S. industry as a percentage of GNP is the lowest of the major industrialized nations (3:6). U.S. manufacturing plants and equipment are noticeably older than the plants and equipment of other industrialized nations, and U.S. defense industry equipment is significantly older than the overall U.S. industry average. Not only is modernization taking place at a slow rate throughout U.S. industry, but defense industry efforts are approximately 50 percent less than comparable U.S. commercial sectors (6:57-58).

Many reasons have been identified for the defense industry's lack of willingness to undertake increased capital investments. Congress has cited high inflation, high interest rates, government over-regulation, tax policies, and short run profit maximizing as the major constraints to increased investment (24:17). Kluter identified the attempted maximizing of return on investment and short run profits, uncertainty of the defense market, and low profits relative to commercial markets as primary reasons for sagging defense industry investment (14:18-21). Gansler (6:58-59) proposed fourteen causes for the low level of investment by the defense industry. Some of Gansler's theories are the nature of government contracts, cyclic DOD market activity, existing excess capacity, and the perception that future capital investment is not required to maintain current position in a shrinking marketplace. Whatever the specific reasons, the lack of capital investment has contributed significantly to the present trend of decreasing productivity growth in the defense industry.

Technology, the other primary contributor to productivity, is directly related to capital. Capital is required not only for the research and development of new technologies but also for the implementation of new or existing technologies into a contractor's facility (14:3). Therefore, the previously described reluctance to increase

capital investments adversely influences the degree of technology modernization within the defense industry.

The military commitment to improve industrial productivity began with "Profit 76." The "Profit 76" study examined the defense industrial base's erosion and found that the industry's high return on investment was accompanied by a relatively lower return on sales (16:4). The high return on investment was "traceable to a markedly low level of investment by defense contractors [16:4]." A following study, "Payoff 80," focused on defense industry productivity and identified four major areas, one of which was Tech Mod, as the potential means for improving productivity. However, the "Payoff 80" recommendations only addressed improved policy guidance, better communication of Tech Mod to contractors, and more emphasis on subcontractor Tech Mod (16:6-7). The "Payoff 80" recommendations failed to address specific means for implementing DOD Tech Mod programs.

A Tri-Service Committee is currently developing an Industrial Modernization Incentives Program (IMIP) in support of DOD Acquisition Improvement Program Initiative No. 5, "Encourage Capital Investment to Enhance Productivity" (25). The IMIP's main thrust is a cooperative government-industry venture using contractual incentives to substantially increase capital investments by industry for modernization and productivity enhancement; special

emphasis is being placed on the subcontractor and vendor levels (25:enclosure 1).

Air Force Systems Command (AFSC) is currently attempting to increase contractor capital investments and thereby productivity through two fundamental approaches, "contracting for productivity" and "technology modernization" of contractor facilities. Productivity contracting utilizes contractual arrangements such as multiyear contracts, capital investment incentives, award fees, and special provisions to "incentivize and sustain contractors in increasing productivity [2:i]." AFSC technology improvements consist of two separate programs--manufacturing technology (MANTECH) and technology modernization (Tech Mod).

MANTECH

The Air Force MANTECH Program has existed in various forms since 1947. Originally concerned with U.S. post World War II basic industrial capacity, MANTECH has evolved into an Air Force tool for enhancing contractor productivity (3:15). The Air Force Wright Aeronautical Laboratory Materials Laboratory Manufacturing Technology Division (AFWAL/MLT) is currently responsible for the development of new manufacturing technologies for a specific need and MANTECH program management. The MANTECH effort is centered on developing new productivity improving technologies, but MANTECH does not directly link the technologies with

production applications (2:ii). The MANTECH program has had numerous successes in establishing and implementing manufacturing technology advances, but the successes have consisted primarily of individual discrete projects (3:15). However, an extension of the MANTECH effort across many programs is now evident in Tech Mod.

Technology Modernization

Tech Mod is a broad-based program by which the Air Force is attempting to improve the overall health of the defense industry by combining new and existing technologies with the elements of "contracting for productivity" to achieve optimum results in a total factory setting (2:ii). Contractual arrangements, as part of a joint Air Force-industry "business deal," establish the Air Force as an active participant in the systematic process that combines manufacturing technologies with increased contractor capital investment to modernize contractor facilities, improve return on investment, and reduce acquisition costs (2:1-2). To obtain the aforementioned objectives, Tech Mod progresses through three distinct phases.

Phase I is an in-depth factory analysis examining the contractor's total manufacturing process and identifying potential areas for technology modernization improvements. When possible, the "top-down" evaluation is accomplished by using one of the computer-aided evaluation

programs. At the conclusion of Phase I, a "business deal" establishing the Tech Mod ground rules is negotiated between the Air Force and the contractor. The business deal addresses general program scope, proposed government/ contractor investment ratios, contemplated technologies, return on investment expectations, benefit-sharing arrangements, implementation schedules, incentives, information transfer requirements, and contract termination liabilities, thereby forming the basis for the remaining phases. Phase I funding can be provided either by the contractor or Air Force "seed" money, or a combination of the two financing methods (2:27-30).

Phase II further defines the specific technology and factory enhancement requirements of the contractor. Plans for implementing the improvements into the production process are developed and any existing deficiencies in presently available state-of-the-art technologies are identified (2:33-34).

Phase III implements the Tech Mod into the contractor's facility. The necessary capital investments are made at this time, resulting in

> . . . an integrated, efficient, modernized factory tailored to specific industrial requirements and capable of producing and maintaining Air Force weapons systems at substantial validated savings [2:34].

Subcontractor Tech Mod

"By concentrating on modernizing the subcontractor network, an excellent opportunity exists to affect a very large portion of the industrial base [3:113]." AFSC has proposed two methods of managing subcontractor Tech Mod. One, which has not yet been operationally attempted, calls for a third party administrator for similar product subcontractors. The administrator would not have a direct relationship with a major system and could conceivably be a military unit, a governmental office, or a nonprofit organization (2:106). The other method of managing Tech Mod is through the prime contractor for subcontractors involved in a particular program. The second method is currently being employed by the F-16 and Advanced Medium Range Air to Air Missile (AMRAAM) programs (3:103).

Industrial Technology Modernization Program (ITMP)

In September 1980, the F-16 System Program Office (SPO) contracted General Dynamics, the F-16 program's prime contractor, to perform an initial feasibility study of technology modernization for F-16 subcontractors. The study surveyed each F-16 vendor[1] concerning corporate goals, desired involvement in a Tech Mod Program, and potential

[1]Throughout the discussion of the ITMP, the term vendor is used synonymously with subcontractor and refers to any F-16 subcontractor under direct contract with General Dynamics.

candidate technology modernization projects (2:103-104; 9:1). The survey results led to the decision to proceed with a F-16 Tech Mod program designated the ITMP, and in January 1981 General Dynamics was awarded a contract to administer the ITM Program. The ITMP provides

> . . . the management, control, financial incentives, and technology assistance necessary to stimulate vendor implementation of new technology, capital equipment, and manufacturing processes [2:104].

Table 1 lists the F-16 ITMP target contracts by phase and fiscal year. In FY 84 the goal of the ITMP is to negotiate eight Phase I contracts, eight Phase II contracts, and five Phase III contracts. Fiscal year funding is also listed in Table 1; program funding for FY 84 is $13 million. It is important to note that the ITMP funding is included in the F-16 multiyear contract; therefore, continuance of the ITMP is guaranteed through fiscal year 1985 (12:9).

TABLE 1

F-16 ITMP PLAN FOR FISCAL YEARS 1982-1985 (10:140)

	FY 82	FY 83	FY 84	FY 85
Phase I	10	8	8	8
Phase II	1	9	8	8
Phase III	0	3	5	12
Annual Funding (000,000)	$3.623	$11	$13	$13

ITMP efforts are categorized according to level of program risk and degree of government financial participation. In Category 1 programs the vendor receives no government funding. The Category 1 programs are usually "low-to-moderate risk projects with moderate-to-high vendor return on investment (ROI) [2:105]." Vendors are not required to perform a formal factory analysis, nor is cost tracking/reporting required. Government surveillance is minimized, and there are no technology sharing requirements. A no-cost contract is issued to acknowledge acceptance of a Category 1 ITM program (6:2-6 to 2-8).

Category 2 programs feature government funding during Phase I and/or Phase II. However, no government funding is available for Phase III (7:19). The Category 2 programs are primarily "moderate-to-high risk tasks which significantly advance the state-of-the-manufacturing art [2:105]." Activities that may be completely or partially funded include studies, technology development, cost effectiveness analysis, software development, program management, and related consulting fees (12:7). Formal proposals must be submitted for any phase for which government funding is desired, and full disclosure and industry-wide dissemination is required for any data resulting from government-funded tasks (8:2-9 to 2-12; 2:105).

Contractor participation in productivity enhancing/cost reduction initiatives such as the ITMP "are not driven

by necessity--they are driven by the desire to earn a satisfactory return on invested capital [8:2-12]." Both Category 1 and Category 2 program participants are allowed to retain an agreed-upon share of cost savings so that the negotiated vendor ROI is realized. Additionally, guarantees can be negotiated which provide the vendor compensation in the event that the government prematurely terminates a program's contract (7:18). "The important point to remember is that the program must benefit both the Government and the Vendor [8:2-13]."

Eligibility for participation in the ITMP depends solely on whether or not a firm is a F-16 vendor. Other criteria such as F-16 business volume and potential savings, technology transfer potential, F-16 program enhancement, proposed Phase II funding category, and the productivity, delivery, surge capability, quality and cost impact on F-16 materials are then used for vendor selection and establishment of program and project priorities (10:165).

The extent of the F-16 Tech Mod effort is limited, as application at the subcontractor level is in the infant stages. Additionally, information from empirical studies in the area of subcontractor Tech Mod programs is either nonexistent or inconclusive.

Research Questions

Three research questions provided the overall framework for guiding the research effort which investigated the area of technology modernization at the first-tier subcontractor level.

1. Are significant differences evident in the market, business, and financial factors that describe the first-tier subcontractors currently participating in the F-16 ITMP from the nonparticipating subcontractors?

2. What are the most significant capital investment factors that could positively influence a subcontractor's technology modernization decision?

3. What DOD incentives should be offered that incorporate the capital investment factors identified as most significantly influencing a subcontractor's technology modernization decision?

Summary and Research Overview

The problems of low productivity, old plants and equipment, and low levels of capital investment within the defense industry, particularly at the subcontractor levels, were discussed in this chapter. Technology Modernization (Tech Mod) programs have been developed as one means of enhancing productivity through defense contractor investments in modern plants and equipment. The researchers' primary objective was to develop a set of capital investment

incentives that should be offered as part of the DOD subcontractor Tech Mod effort designed to motivate increased capital investments by defense subcontractors for modern plants and equipment. This chapter concluded with the three questions that served as the framework for guiding the direction of the authors' research study.

Chapter II details the methodology used by the researchers during data collection and analyses. The third chapter discusses the data analyses and resultant findings. Chapter IV presents the conclusions drawn from the research findings and the researchers' recommendations for motivating increased participation in the DOD subcontractor Tech Mod effort. Chapter IV also contains an evaluation of the researchers' recommendations by several Air Force technology modernization "experts," the researchers' comments regarding the implications of the research study, and recommendations for future study.

CHAPTER II

RESEARCH METHODOLOGY

Introduction

The first chapter presented the major causes for the deterioration of the defense industrial base. In response to this national problem, the F-16 System Program Office (SPO) initiated the Industrial Technology Modernization Program (ITMP) to provide a means for incentivizing and motivating F-16 defense subcontractors to provide capital investment for new technology, plants and equipment, and manufacturing processes. This chapter defines the universe and target populations, describes the data collection method, defines the factors in operational terms, and discusses the data analysis techniques.

The Universe

For this research study the universe consisted of all U.S. defense contractors. As previously discussed, there are no clear lines separating the prime and subcontractor levels, for a prime contractor in one program may well be concurrently a subcontractor in a different program.

Target Population

Within the defined universe, there are many subgroups of defense contractors. One subgroup consists of

the first-tier subcontractors for a specific program. As previously discussed in Chapter I, any element (defense contractor) in the universe potentially may become a first-tier subcontractor on a program. Also discussed in Chapter I was the "multi-service link" that exists in the subcontractor network. The link illustrates how subcontractors can function across both program and military service lines. For this research, the first-tier subcontractors for one Air Force, major weapon system acquisition program were considered representative of the subgroup of first-tier subcontractors. The researchers considered the elements (first-tier subcontractors) of the target population as representative of the universe.

The F-16 program was selected for this research effort, because the F-16 ITMP was considered to be the "most extensive such venture [2:8]." The target population consisted of forty-seven first-tier subcontractors who had received ITMP orientation. The target population was further segregated into four mutually exclusive subgroups: (1) the thirteen first-tier subcontractors who elected to participate in the ITMP (participants), (2) the six first-tier subcontractors who elected not to participate in the ITMP (nonparticipants), (3) the eighteen first-tier subcontractors who were considering possible ITMP participation ("consideration"), and (4) the ten first-tier subcontractors who had only received initial ITMP orientation

("oriented"). Figure 4 depicts the subdivision of the target population into the four mutually exclusive subgroups and illustrates the composition of the sample used in the research.

Content of the Study

The overall research plan involved three phases (see Figure 5). Phase I was the field research phase, Phase II was the analysis and identification phase, and Phase III was the recommendations and evaluation phase. Phase I was used to collect the information necessary to answer Research Question No. 1 and to provide the information for identifying the factors pertinent to Research Question No. 2. The analysis and identification phase answered Research Questions No. 1 and No. 2 and provided the necessary information for Phase III. The recommendations and evaluation phase answered Research Question No. 3 and fulfilled the overall research objective; investment incentives were developed and feedback was obtained from field "experts" (see Figure 5). The following sections further develop the individual research phases.

Phase I--Field Research

The field research phase consisted of a one-time visit to each sampled F-16 first-tier subcontractor facility to gather data that became the input to the Phase II statistical analyses. An interview guide was the data

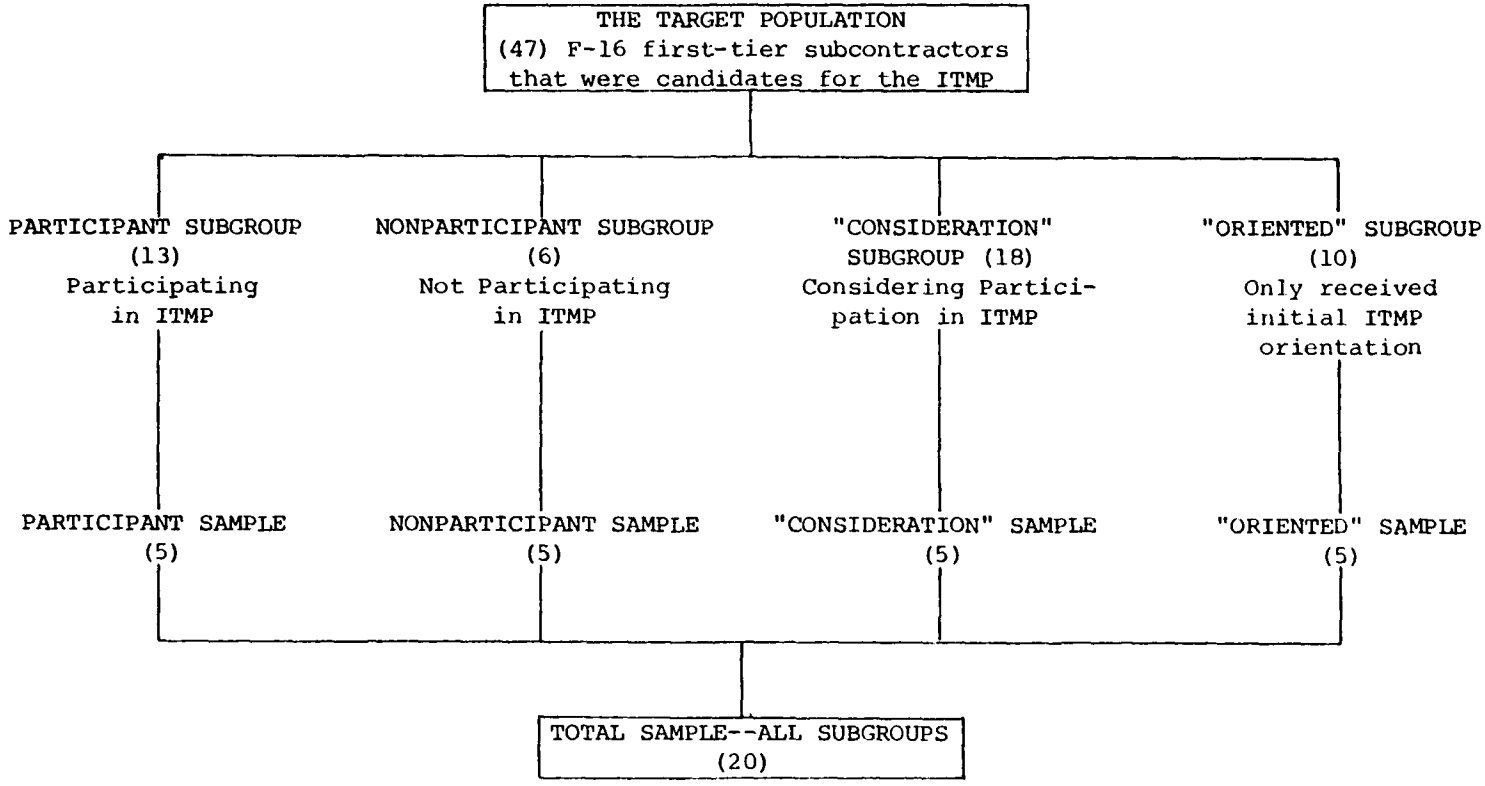


Fig. 4. Breakdown of Target Population into Sample Subgroups

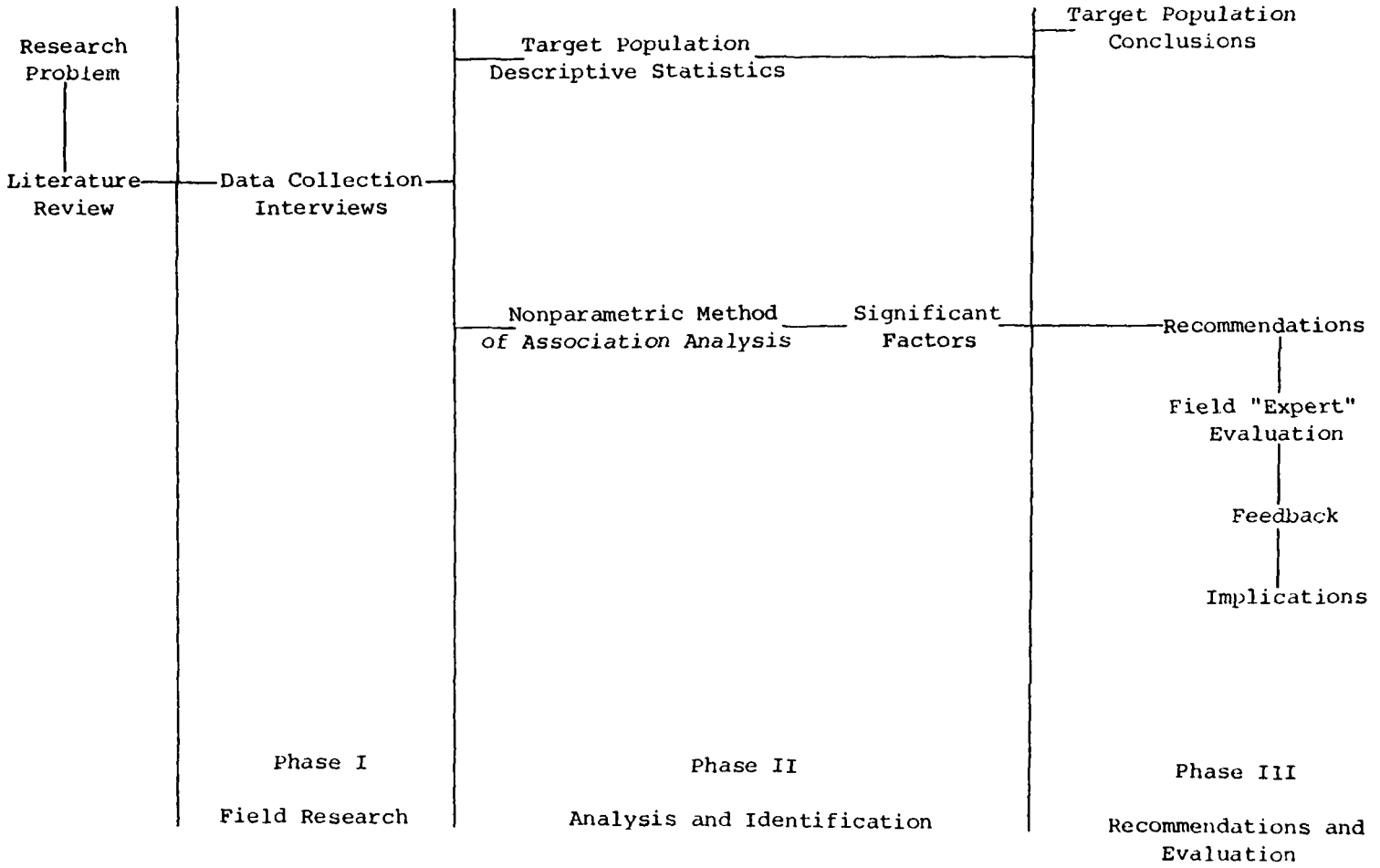


Fig. 5. Research Flow and Phase Overview

collection instrument used in the field research phase. A complete description of the interview guide is contained in a subsequent section.

Phase II--Analysis and Identification

Phase II had a two-fold objective. First, the target population was statistically described using the Phase I data. Second, a nonparametric analysis of the capital investment decision factors was performed using the Kendall coefficient of concordance W and the Friedman two-way analysis of variance by ranks test.

The coefficient of concordance was used to determine if agreement existed among the rankings of the set of fourteen capital investment factors (see Appendix A) by the respondents in each of the four mutually exclusive subgroups of F-16 first-tier subcontractors and within the entire sample.

Next, the Friedman two-way analysis of variance by ranks was used to verify the results that were obtained from using the Kendall coefficient of concordance W technique. The Friedman test was used to demonstrate that the four mutually exclusive subgroups were from the same population and that the four subgroups agreed on the relative rankings of the fourteen capital investment factors.

Kendall has suggested "that the best estimate of the true ranking of N objects when W is significant is by

the order of the various sums of ranks R_j [21:238]."

Furthermore, Siegel points out that the Kendall coefficient of concordance W

> . . . has special applications in providing a standard method of ordering entities according to consensus when there is available no objective order of the entities [21:239].

Thus, the researchers used the sums of the ranks (R_j) to establish the relative importance of the fourteen capital investment factors as the input to Phase III of the research.

Phase III--Recommendations and Evaluation

The ordering of the fourteen capital investment factors was the basis for the researchers' recommendations on investment incentives that should be offered by the government to defense subcontractors as part of a comprehensive DOD Tech Mod program. The researchers' recommendations for investment incentives were developed using those capital investment factors that were identified as most significantly influencing a subcontractor's decision to modernize plant and equipment. The recommendations were evaluated by Air Force Systems Command (AFSC) and Aeronautical Systems Division (ASD) technology modernization "experts."[2] The responses from the "experts" were

[2]The "experts" were DOD personnel currently involved in developing guidelines for Tech Mod programs.

essential in validating the practical usefulness of the researchers' incentive recommendations designed to motivate increased participation in DOD Tech Mod efforts throughout the defense subcontractor level.

Research Design

There have been many definitions of "research design." One definition provided by Kerlinger is that "research design is the plan, structure, and strategy of investigation conceived so as to obtain answers to research questions and to control the variance [4:83]." Selltiz, Wrightsman, and Cook stated that a research design is the blueprint for data collection, measurement, and analysis that aids the researcher by posing crucial questions (4:90). Research design questions addressed the type of method to be used for data collection, whether an intensive study of a small sample was preferred over a broader study of a larger sample, and whether the analysis should be quantitative or qualitative (4:83). For the purpose of this study, the research design was viewed in terms of an investigative plan, structure, and strategy, that incorporated the alternatives to the mentioned crucial questions, recognizing the constraints of time, existing data, and the field environment.

The investigative plan or overall outline refers to the sources and types of information relevant to the

research questions (4:83). Chapter I described the historically recurring deficiencies in the U.S. defense industry as a foundation for understanding the necessity for technology modernization--particularly at the subcontractor level. The ITMP literature review revealed the progress that has been made in developing a specific program aimed at correcting the defense industry's lack of productivity stemming from the low level of capital investment by defense contractors for modernization of plants, equipment, and manufacturing technologies.

Kerlinger states that the research structure is the outline, the scheme, and the paradigm of the operation of the variables (13:300). The complete lack of related empirical studies in the area of technology modernization required the researchers to develop a research structure which provided the framework for understanding the factors and their interrelationships.

Research Questions No. 1 and No. 2 were operationalized to focus on the market, business, financial, and capital investment factors suspected to describe F-16 first-tier subcontractors. Answering Research Question No. 1 characterized the participant and nonparticipant subgroups and determined if the two subgroups were differentiated in terms of the market, business, and financial factors. Answering Research Question No. 2 identified the capital investment factors that were considered most significant

by first-tier subcontractors toward motivating capital investments for technology modernization. The identified factors provided the framework for the investment incentive recommendations. Evaluation of the recommendations by field experts enabled Research Question No. 3 to be answered concerning the investment incentives' usefulness as part of a comprehensive DOD technology modernization program.

Finally, the research strategy specifies the approach used for collecting and analyzing data. Strategy is the "blueprint" for answering "how" the research objective was reached (4:83). The remainder of this chapter discusses the specific methods of data gathering and analyses used in Phases I (Field Research) and II (Analysis and Identification).

Phase I--Field Research

Festinger and Katz state that the best examples of survey research use personal interviews as the principal data-gathering method (5:412). The need to acquire valid data to identify previously uninvestigated subcontractor characteristics required a direct communicative method to motivate the respondent subcontractors to answer market, business, and financial questions accurately. The data collection method that facilitated the accuracy requirement was the personal interview.

Interview Schedule

The data considered essential to answer the research questions were collected by conducting personal interviews using the interview schedule contained in Appendix B.

The interview schedule consisted of three types of questions: fixed-alternative questions, open-ended questions, and summated rating scale (Likert-type) questions.

According to Festinger and Katz, fixed-alternative questions offer a choice among two or more alternatives and provide the decided advantage of achieving greater uniformity of measurement and greater reliability (5:482-483).

The researchers were interested in obtaining the respondents' attitudes and opinions concerning various factors under study. Likert-type questions are a set of attitude items, all of which are considered to be of approximately equal "attitude value," and to each of which the interviewee responds with some degree of disagreement or agreement (5:496). Selltiz states that a feature common to all rating scales is that the respondent places the object being rated at some point along a continuum in one of an ordered series of categories--a numerical value is given to the point or the category (20:255). The researchers developed a series of five-point Likert-type questions that assigned the respondents' attitudes a numerical value. The numerical value was used as an ordinal measurement.

Open-ended questions were included in the interview schedule where the researchers desired specific and accurate interval measurements. Throughout the interview guide, space entitled "comments" was used to gather additional responses in an open-ended manner. The "comments" sections provided the researchers the opportunity to collect information not originally anticipated when the research plan was developed.

Overall, the interview schedule consisted of a structured set of questions that were asked orally with the researchers recording the responses in writing. The advantages of the interview schedule were: (1) the questions were asked in a standardized format and sequence, (2) measurement reliability consequently was increased, and (3) the data collection was not affected by the researchers' lack of interview experience (4:125).

Following the interview schedule's initial drafting, individuals from the F-16 and B-1B System Program Offices, the Aeronautical Systems Division's Directorate of Manufacturing and Quality Assurance Office, the General Dynamics' ITMP Office, and Headquarters U.S. Air Force Contracting/Manufacturing Directorate evaluated the interview schedule questions for relevance and completeness in the area of technology modernization. Feedback received from the interview schedule review was incorporated into a

revised interview schedule which was the data-gathering instrument subsequently used during the field research phase.

Pilot Study

Prior to the actual data collection in Phase I (Field Research), the researchers tested the interview schedule. The two subcontractors interviewed during the pilot study were selected from those defense subcontractors in attendance at the Fourth Annual Industrial Modernization Review, hosted by the General Dynamics Corporation, Fort Worth Division, 9-10 November 1982. The "multi-service link" that was characteristic of the target population established for the authors' research project was evident for the two subcontractors interviewed during the pilot study.

Throughout the pilot study, both researchers were present during the interviews. The pilot study assured standardization of interview techniques and recording of responses to interview questions and provided the researchers with a common "reference base" for data collection during Phase I.

Interview Technique

Generally, the interview time spent with each respondent varied from fifty minutes to a maximum of ninety minutes, with the average interview time being approximately

one hour. All interview sessions were conducted in the following manner:

1. The researcher conducting the interview introduced himself, his background, the purpose of the interview, and the general focus of the research.

2. The researcher emphasized that all information obtained during the interview was to be treated with anonymity and that the respondent's answers should reflect corporate views and not personal opinions.

3. The respondent was provided a definition list of key terms (see Appendix C) appearing in the interview schedule and was given the opportunity to review the definitions prior to the interview.

4. The researcher recorded demographic information concerning the respondent's job title and employment history, the subcontractor's corporate structure, the number of years in business, the number of employees, and primary products produced.

5. The researcher introduced Section II of the interview schedule (market environment) and recorded the respondent's answers.

6. The researcher explained the structure of the Likert-type questions and the method of recording answers to the interviewee and continued the interview session by recording responses to Section III of the interview schedule.

7. The researcher described the remaining sections of the interview schedule and recorded the interviewee's responses.

8. The researcher concluded the interview session by providing the respondent with the opportunity to reemphasize any previously stated comments or to introduce new information the respondent considered relevant to technology modernization.

The Sample

The sampling frame concept is closely related to the population--"It is a list of elements from which the sample is actually drawn [4:151]." Ackoff points out that disproportionate stratified sampling offers an advantage when a comparison of strata is an important aspect of the research and that increased efficiency is realized when equal size samples are drawn from each stratum (1:110). Furthermore, Slonim states that the final sample will be a probability sample provided that a random method of selection is used to choose the sample units from each strata (23:52). However, the expected benefits of stratified sampling will not accrue unless the basis of strata selection is logically related to the population characteristics under investigation (23:52).

The Industrial Technology Modernization Program (ITMP) Office at General Dynamics, Fort Worth Division,

provided the researchers with a listing of the target population elements. The target population elements were divided into four mutually exclusive strata (subgroups) on the basis of the subcontractors' (elements) degree of involvement in the ITMP. The researchers selected equal size samples of five F-16 first-tier subcontractors from each strata (see Figure 4 on page 26) using a random number table. The General Dynamics, Fort Worth Division, ITMP Manager then provided the researchers with the name of an executive within each sampled first-tier subcontractor organization who was "knowledgeable" of technology modernization issues and familiar with corporate decision-making criteria. The sample selection procedure helped to assure that all the executives (respondents) had a common knowledge base regarding their respective corporation's policies and views concerning the Industrial Technology Modernization Program (ITMP).

The twenty executives (five executives from each of the four subgroups) had been employed by their respective corporations a total of 310 years, with an average employment time of 15.5 years per executive. Of their total employment time, the twenty executives had been in a government business division within the corporation for a total of 290 years, an average of 14.5 years per executive. In the area of direct interest--technology modernization--the twenty executives had a total of 37

years of experience, averaging 1.85 years per executive. Overall, the researchers considered the twenty executives experienced in defense-related business and in technology modernization, realizing that the ITMP had been in existence less than three years. Additionally, the twenty executives had been employed a total of 226.5 years by other government and commercial contractors (see Table 2).

TABLE 2

EMPLOYMENT HISTORY OF THE SAMPLED F-16
FIRST-TIER SUBCONTRACTOR EXECUTIVES

	Years Employed Within Each Category	
Employment Category	Total	Mean
Overall Corporation	310	15.5
Government Business Division	290	14.5
Technology Modernization Office	37	1.85
All Other Government Contractors	142.5	7.13
All Other Commercial Contractors	84	4.2

The twenty interviewees represented a broad range of functional activities (see Table 3). The number of executives in the traditional areas of operations, manufacturing, marketing / sales, engineering, contracting, and program management were approximately equal to the sample representation found in a newly-created functional area entitled "ITM Program Management." The researchers felt

TABLE 3

SAMPLE REPRESENTATION BY FUNCTIONAL AREA

Functional Area	Number of Executives Interviewed
ITM Program Management	3
Program Management	3
Operations	3
Manufacturing	4
Marketing/Sales	3
Contracting	2
Engineering	2
Total	20

that the number of executives in the nontraditional ITM Program Management area was warranted, considering the area of investigation (technology modernization), the diversity of subcontractor organizations, and the interest being placed on the ITMP at the subcontractor level. Finally, the balance exhibited among the functional areas helped to assure the researchers that all management areas had been included in the sample and that the information gathered through the interview process was not unduly influenced by a particular area of management expertise.

Identification/Definition of Factors

To answer the three research questions, several market, business, financial, and capital investment decision factors were identified. The factors which were the basis for developing the interview schedule questions were identified by the researchers based on a suspected correlation between certain market, business, and financial considerations and subcontractor capital investment decisions. The selection of nonparametric statistical techniques for the data analysis permitted factor measurement levels to be either nominal, ordinal, interval, or ratio. A factor's measurement level resulted from the researchers' determination of the required level of preciseness of measurement for each factor and each factor's role in differentiating between the four first-tier subcontractor subgroups. Identification of each factor, the measurement level, and an operational definition follows:

A. Market Environment (nominal)--an objectively derived factor that placed a F-16 first-tier subcontractor in a theoretical economic market along the continuum ranging from perfectly competitive to monopolistic. The market classification resulted from subcontractors' responses to specific interview questions regarding:

1. Number of competitors (nominal)--the number of defense subcontractors competing to offer

product(s) of the same type as the respondent first-tier subcontractor.

2. Number of buyers (interval)--the number of defense prime contractors requiring the product(s) offered by the respondent first-tier subcontractor.

3. Knowledge of competition (ordinal)--the amount of market, product, and competitive information the respondent first-tier subcontractor had regarding other subcontractors.

4. Cross elasticity of demand (ordinal)--the responsiveness of a change in the quantity of the respondent first-tier subcontractor's product(s) to a change in price of another subcontractor's similar product(s).

5. Freedom of exit and/or entry (ordinal)--the ability of the respondent subcontractor to freely enter and/or exit the DOD first-tier subcontractor market.

B. Perceived Market Environment (nominal)--a subjective determination by the respondent first-tier subcontractor of the firm's market environment along the continuum from perfect competition to monopoly.

C. DOD Business (ratio)--a percentage indication of the respondent first-tier subcontractor's DOD and F-16 business compared to total business for fiscal years 1980-82.

D. Investment Financing (nominal)--an indication of the type(s) of internal and/or external sources used to finance capital investments.

E. Capital Investment Decision Rules (ordinal)--an indication of what methods were used by the respondent first-tier subcontractor to decide among alternative capital investment efforts.

F. Capital-Labor Mixture (ordinal)--an indication of the capital intensiveness of the respondent first-tier subcontractor.

G. Age of Capital Equipment (interval)--an indication of the state-of-the-art of the respondent first-tier subcontractor's equipment and production processes and of the potential need for plant and equipment modernization.

H. Labor Force Composition (interval)--numerical indication of the age and skill level of the respondent first-tier subcontractor's workforce.

I. Need to Modernize (ordinal)--a determination by the respondent first-tier subcontractor of the requirement to modernize plant and equipment for economic growth and competitive advantage.

J. Planning Period (nominal)--an indication of the respondent first-tier subcontractor's planning period (in terms of months) for business forecasting and capital investment decisions.

K. Investment Motivators (ordinal)--a determination by the respondent first-tier subcontractor of the factors that were considered most significant in capital investment decisions (see Appendix A).

Table 4 describes the interrelationships between specific interview schedule questions, the aforementioned factors, and the three research questions.

Phase II--Analysis and Identification

McClave and Benson state that statistics mean "numerical descriptors [15:2]." Furthermore, the applications of statistics include describing large masses of data and making inferences from the analysis of some set of sample data (15:2). The analysis and identification phase (Phase II) of the research specifically answered Research Question No. 1 by quantitatively and qualitatively describing the ITMP participant and nonparticipant subgroups and determining if the two subgroups significantly differed. Second, Research Question No. 2 was answered using the nonparametric Kendall coefficient of concordance W, the Friedman two-way analysis of variance by ranks test, and a criterion test developed specifically for the study by the researchers. The specific analytical techniques allowed the most significant capital investment factors to be identified and provided the inputs necessary to develop

TABLE 4

RESEARCH QUESTIONS-FACTOR-INTERVIEW SCHEDULE
QUESTION INTERRELATIONSHIPS

Research Question Number	Factor	Interview Schedule Question Number(s)
1	market environment	1, 2, 3, 4, 5, 7, 8, 9
	perceived market environment	6
	DOD business	16, 17
	investment financing	24
	capital investment decision rules	14, 15, 22, 23
	capital-labor mixture	10
	age of capital equipment	20
	labor force composition	11, 18, 19
	need to modernize	12
	planning period	21
2	investment motivators	Section V
3	investment motivators	13, Section V

a set of investment incentives to answer Research Question No. 3. Phase II data are found in Appendices D, E, and F.

The Statistical Tests

Siegel points out that "a nonparametric statistical test is a test whose model does not specify conditions about the parameters of the population from which the sample was drawn [21:31]." Additionally, the nonparametric tests' assumptions are fewer and much weaker than the assumptions required of the many parametric tests, and most nonparametric tests apply to data in at least an ordinal scale, while some tests apply in a nominal scale (17:85). The measurement level of the previously defined capital investment factors was ordinal when the factors were ranked, and an ordinal, Likert-type scale was used to determine the influence of the capital investment factors as motivators for technology modernization. Therefore, the researchers determined that nonparametric tests were the most appropriate tests for the data analysis.

The advantages of the nonparametric test selection were weighed against the disadvantages of not selecting parametric tests. The level of measurement achieved in the data collection effort and the researchers' limited knowledge of the target population's distributions (21:32) were significant in determining that the advantages of

nonparametric statistical tests were greater than the disadvantages. Specifically, the advantages of nonparametric tests included:

1. probability statements obtained from most nonparametric statistical tests are exact probabilities, regardless of the shape of the population from which the sample is drawn;

2. if sample sizes up to N = 6 are used, there is no alternative to using a nonparametric statistical test unless the exact shape of the population is known; and

3. nonparametric statistical tests can treat data which are inherently in ranks, as well as data whose seemingly numerical scores have the strength of ranks. The researcher does not have to specify how much more or less of a characteristic exists, only that a subject of the research has more or less (21:32-33).

Kendall Coefficient of Concordance W

Gibbons states that when "K" observations or judges are given the same set of "N" objects to rank, the Kendall coefficient of concordance W is used for testing whether or not the "K" sets of rankings are independent and for finding a measure of the strength of the relationship between the rankings (11:250). As a solution to the problem of determining the overall agreement among the subcontractors' rankings of the fourteen capital investment

factors, the Kendall coefficient of concordance provided an index of the divergence of actual agreement from perfect agreement (21:230). Specifically, the coefficient of concordance provided a linear function of the average of the coefficients of rank correlation for all pairs of the rankings (11:251). The value of W, the coefficient of concordance, reflected the degree of variance among the fourteen factors' sum of ranks and the degree of agreement among the first-tier subcontractors (21:230-231).

Calculating the Value of W. To compute the value of W, the data were placed in a K x N table, with K representing the number of first-tier subcontractors either in a specific subgroup (K = 5) or in the entire sample (K = 20), and N representing the number of capital investment factors (N = 14). The specific steps in the computation of W, the coefficient of concordance, were:

1. For each capital investment factor, determine R_j, the sum of the ranks assigned to that factor by each first-tier subcontractor.

2. Compute the mean of the fourteen R_j values. Express each individual R_j as a deviation from the mean of the fourteen R_j values. Square the deviations and sum the squares to obtain the value for "s."

3. Calculate the value of W, the coefficient of concordance, using the formula:

$$W = \frac{s}{\frac{1}{12}K^2(N^3-N)}$$

4. If the proportion of ties in the K sets of ranks was large, calculate for each of the K subcontractors a value for T_K, where t = the number of observations tied for a given rank.

$$T_K = \frac{\Sigma(t^3-t)}{12}$$

Then, calculate the value for W, the coefficient of concordance, using the formula:

$$W = \frac{s}{\frac{1}{12}K^2(N^3-N) - K\sum_{1}^{K} T_K}$$

where $\sum_{1}^{k} T_K$ sums all the values of T_K for all the K rankings.

Testing the Value of W. The significance of the computed value of the coefficient of concordance W was then tested to determine the probability associated with the occurrence under a null hypothesis (H_0) of a value as large as the "s" with which the H_0 was associated. For large sample sizes (i.e., N larger than 7), the chi-square distribution was used to determine the probability associated with the occurrence under H_0 of any value as large as the computed W value (21:236).

The null hypothesis (H_0) tested was that the K sets of rankings were unrelated (21:237), meaning no agreement existed among the "K" subcontractors regarding the ranking of the fourteen capital investment factors. The null hypothesis was tested by first computing a chi-square (χ^2) value using the formula

$$\chi^2 = K(N-1)W$$

with degrees of freedom (df) equal to N - 1. By reference to a chi-square distribution for a particular level of significance and a value of df = N - 1, the computed value of χ^2 was compared with the tabulated (critical) χ^2 value. If the computed χ^2 value equaled or exceeded the critical χ^2 value, the null hypothesis was rejected at the stated level of significance. The rejection of H_0 meant that the agreement among the subcontractors' rankings was higher than it would have been by chance.

Level of Significance. Siegel states that a researcher chooses to set the level of significance based upon the "importance or possible practical significance [21:9]" of the research findings. Furthermore, in reporting findings, the researcher should indicate the actual probability level associated with the findings, thus allowing the reader to use personal judgment in deciding whether or not the null hypothesis should be rejected (22:9).

Realizing the importance of determining agreement among the first-tier subcontractors, the researchers determined that a .05 level of significance was acceptable for testing H_0 under the Kendall coefficient of concordance W method. However, the actual probability of occurrence was reported with all research findings to allow individual determination of rejection of the null hypothesis.

Interpretation of the Value of W. A high or significant value of W may be interpreted as meaning that the first-tier subcontractors were applying essentially the same standard in ranking the fourteen capital investment factors. However, it should be emphasized that a high value of W does not mean that the agreed upon ranking was correct or an objective one (21:238).

Kendall suggests that the best estimate of the preferential order of N objects is provided, when the value of W is high or significant, by the order of the various sums of the ranks, R_j (21:238). After determining the existence of agreement among the first-tier subcontractors, both within the four specific ITMP subgroups and within the entire sample of twenty first-tier subcontractors, the researchers used this "special application" of the coefficient of concordance (21:239) to obtain an ordering of the fourteen capital investment factors. The lowest R_j value meant that the associated capital investment factor had received the highest ranking by the sampled first-tier

subcontractors. Consequently, by arranging the R_j values in increasing order of magnitude, the researchers were able to ascertain the relative ordering and importance of the fourteen capital investment factors.

The relative rankings of the fourteen capital investment factors as determined by the sample were later used to develop a set of investment incentives during Phase III (Recommendations and Evaluation) of the research. Finally, the rankings from each of the four ITMP subgroups were the inputs to the Friedman two-way analysis of variance by ranks test.

The Friedman Test

The Friedman two-way analysis of variance by ranks test was used to determine if the four ITMP subgroups were drawn from the same population (21:166). Since the data were in an ordinal scale, the data were placed in a two-way table having four rows and fourteen columns. The four rows represented the four ITMP subgroups, and the columns represented the fourteen capital investment factors (see Table 5). The entries in each row represented the relative rankings of the fourteen factors from each subgroup as determined by the Kendall coefficient of concordance method. The null hypothesis (H_0) tested at the previously determined .05 significance level was that the different columns of ranks (i.e., the rankings by the four ITMP subgroups)

TABLE 5

TABLE FOR FRIEDMAN TEST OF THE FOURTEEN CAPITAL INVESTMENT FACTORS

ITMP Subgroup	Capital Investment Factors													
	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Participant														
Nonparticipant														
"Consideration"														
"Oriented"														

did not differ, meaning that the four subgroups did not agree on the rankings of the capital investment factors. The alternate hypothesis was that the different columns of ranks did differ, meaning there was agreement by the subgroups regarding the rankings. The specific steps used in testing H_0 at the .05 level of significance included:

1. Placing the rank order scores in a N x K table with N rows (one row for each of the four subgroups) and K columns (one column for each of the fourteen factors),

2. Summing the ranks to obtain a R_j value for each column, and

3. Computing a value for χ^2_{ranks} using the formula

$$\chi^2_{ranks} = \frac{12}{NK(K+1)} \sum_{j=1}^{K} (R_j)^2 - 3N(K+1).$$

4. As the sampling distribution of χ^2_{ranks} was approximated by the chi-square distribution with df = K-1, a critical value for χ^2 was obtained from the chi-square distribution table, using a .05 level of significance and df = 13.

5. The χ^2_{ranks} was compared against the critical χ^2 value. If the χ^2_{ranks} was equal to or greater than the critical value, H_0 was rejected (meaning there was agreement among the four subgroups regarding the rankings of the fourteen capital investment factors).

By using the Friedman test, the researchers demonstrated that even though the four ITMP subgroups were in various stages of involvement/noninvolvement with technology modernization efforts, all the subgroups came from the same population. The Friedman test allowed generalization concerning the agreed upon rankings of capital investment factors to be applied to the population of first-tier defense subcontractors. However, there was still the requirement to ascertain what specific capital investment factors were considered to be "most significant" by the sample. To answer Research Question No. 2 completely and to identify the "most significant" capital investment factors, the researchers developed a criteria test to be used with a five-point Likert-type scale on each of the fourteen capital investment factors that are contained in Question No. 13 of the interview schedule (see Appendix B).

Eighty-Percent Criterion Test (Mode*)

The relative ranking of each of the fourteen capital investment factors was determined using the twenty subcontractors' rankings of the factors and the Kendall coefficient of concordance W test. Since the results of the Kendall test did not permit the researchers to determine the degree of difference between the rankings, a criterion of at least 80 percent agreement among the twenty subcontractors was used to determine the capital investment

factors considered "most important." The overall objective was to identify the capital investment factors that the subcontractors indicated would have the most positive influence on a capital investment decision to modernize plant and equipment. The "most significant" factors became the basis for the researchers' incentive recommendations designed to motivate subcontractor participation in DOD technology modernization programs.

The researchers' eighty-percent criterion test was applied to the twenty subcontractors' responses (strongly disagree, disagree, uncertain, agree, or strongly agree) regarding the positive influence that each of the fourteen capital investment factors would have on a decision to undertake a technology modernization effort. The prioritized decision rules of the criterion test were:

1. If 80 percent or more of the subcontractors' responses were either in the individual agree or strongly agree category for a particular capital investment factor, then that factor was identified as "most significant" by the researchers, else;

2. If less than 80 percent of the subcontractors' responses for a particular capital investment factor were in the agree or strongly agree category, then the researchers combined the agree and strongly agree responses into an overall "agree category" and applied the eighty-percent

criterion test to the total number of responses in the "agree category" to determine whether a particular factor should be identified as "most significant."

The researchers considered the criterion test statistically correct, since the data being evaluated were on an ordinal scale (19). Furthermore, the research focus was to identify which capital investment factors were considered "most significant" toward motivating a subcontractor's capital investment decision to modernize. Thus, the researchers developed a criterion test that determined the existence of consensus within the sample, rather than differentiating the degree of consensus, to provide the information needed to answer Research Question No. 2.

In addition to identifying the "most significant" capital investment factors, the eighty-percent criterion test was used in the analysis of all other Likert-type question responses. The only modification to the test was consideration of all categories of responses for any particular Likert-type question. The decision rules were:

1. If at least 80 percent of the subcontractors' responses appeared in either the strongly disagree, disagree, uncertain, agree, or strongly agree category, then the researchers reported that categorical response in the findings, else;

2. If less than 80 percent of the responses were either strongly disagree, disagree, agree, or strongly

agree, then a combined "disagree category" and/or "agree category" were tested using the combined responses and the findings reported as either "agree" or "disagree," else;

3. If less than 80 percent of the responses were either in the combined "disagree category" or "agree category," the researchers' finding was reported as "uncertain" for that particular Likert-type question.

Phase III--Recommendations and Evaluation

Phase III used the "most significant" capital investment factors identified in the analysis and identification phase to form the structure for the researchers' recommendations. The recommendations consisted of a set of capital investment incentives the DOD should incorporate into a comprehensive subcontractor Tech Mod program. To completely answer Research Question No. 3, the researchers had several Air Force Technology Modernization "experts" evaluate the researchers' incentive recommendations for usefulness in motivating increased subcontractor participation in existing Tech Mod programs and for integration into future DOD productivity improvement initiatives.

Summary List of Assumptions

1. The data collected for analyzing subcontractor motivation to participate in technology modernization

were independently obtained from the sampled first-tier subcontractors.

2. Individual responses to the interview questions were representative of corporate thinking and not personal opinions.

3. Standardized interview techniques did not bias the data collection.

Summary List of Limitations

1. Due to the absence of any previous studies in the area of subcontractor motivation to undertake technology modernization, no base existed for research replication or research design comparison and/or validation.

2. Since a limited number of first-tier subcontractors have decided to participate in the Industrial Technology Modernization Program, the available sample size was fixed and small.

Summary

The two-fold research objective was to characterize, and if possible, differentiate the first-tier subcontractors that were initially considered as candidates for participation in the General Dynamics F-16 Industrial Technology Modernization Program (ITMP) and to develop a set of investment incentives that should be included in a DOD subcontractor Tech Mod program. The research objectives were translated into three research questions which

subsequently formed the framework for guiding the research study. Data collection was accomplished through a structured interview schedule administered by the researchers to a random sample of twenty F-16 first-tier subcontractors. The random sample consisted of four previously identified equal size subgroups, in which the sampled interviewees were top-management executives that were identified by the General Dynamics ITMP Manager as being "most knowledgeable in Tech Mod and related business and financial areas." Descriptive and nonparametric methods were the primary statistical means used to analyze the data collected during the field research phase (Phase I) of the study. Presented in the following chapter are the results of the analysis and identification phase (Phase II): the primary, corollary, and tertiary findings.

CHAPTER III

DATA ANALYSIS AND FINDINGS

Introduction

The research objectives, as previously stated in Chapter I, were to characterize the F-16 first-tier subcontractors that were candidate participants in the F-16 Industrial Technology Modernization Program (ITMP) and to develop a set of investment incentives intended to motivate increased participation in a DOD Tech Mod program for defense subcontractors.

To accomplish the two research objectives, three research questions were developed. Within the research design, Research Questions No. 1 and No. 2 were operationalized to focus on the market, business, financial, and capital investment factors suspected by the researchers to characterize F-16 first-tier subcontractors. Data collection was accomplished using a standardized interview schedule administered to a random sample of twenty F-16 first-tier subcontractors. Nonparametric statistical methods were used to perform the data analyses. The results of the data analyses became the basis for developing a set of investment incentives which were used to answer Research Question No. 3.

This chapter presents the researchers' primary findings, the analysis of the findings used to answer Research Questions No. 1 and No. 2, and the corollary and tertiary findings resulting from the research effort.

Research Question No. 1

Are significant differences evident in the market, business, and financial factors that describe the first-tier subcontractors currently participating in the F-16 ITMP from the nonparticipating subcontractors?

Primary Findings

To answer Research Question No. 1, interview data were collected on twenty F-16 first-tier subcontractors to include: the type of economic market environment, DOD business as a percentage of total business, investment financing methods, capital investment decision methods, the degree of capital intensiveness, age of capital equipment, labor force descriptors, need to modernize plants and equipment, and planning period used in investment decision making. The data collected on the factors listed above were used to determine if the subgroup of F-16 first-tier subcontractors participating in the ITMP was different from the nonparticipating subgroup of F-16 first-tier subcontractors. Table 6 summarizes the data analysis used to answer Research Question No. 1 by presenting the relevant

TABLE 6

DATA ANALYSIS OF RESEARCH QUESTION NO. 1 FACTORS[a]

Factor	Measurement Level	Descriptive Statistic	Statistical Value by Subgroup: ITMP Participant	Statistical Value by Subgroup: ITMP Nonparticipant
Market Environment				
Number of Competitors (Sellers)	Nominal			
Commercial		Mode	2-5	2-5
Air Force		Mode	2-5	2-5
F-16		Mode	2-5	2-5
Number of Buyers	Interval			
Commercial		Median	24	52
DOD		Median	18	12
Knowledge of Competition	Ordinal			
Air Force		Mode*	"uncertain"	"uncertain"
F-16		Mode*	"uncertain"	"uncertain"

Notes: [a]See Appendix G for a comparison of the four sample subgroups.

Mode* was determined using the eighty-percent criterion test described in Chapter II.

TABLE 6--Continued

Factor	Measurement Level	Descriptive Statistic	Statistical Value by Subgroup: ITMP Participant	Statistical Value by Subgroup: ITMP Nonparticipant
Cross Elasticity of Demand	Ordinal			
USAF Product		Mode*	"uncertain"	elastic
F-16 Product		Mode*	"uncertain"	elastic
Freedom of Entry and/or Exit to DOD Marketplace	Ordinal	Mode*	free to enter and/or exit	not free to enter and/or exit
Perceived Market Environment	Nominal			
Commercial		Mode	oligopoly	oligopoly
Air Force		Mode	oligopoly	oligopoly
F-16		Mode	oligopoly	monopolistic competition
Percent DOD Business	Ratio	Range (Mean)		
FY80				
DOD			40-50[b] (47.5)[c]	24-97 (49.6)
F-16			3-5 (3.67)	0.6-15.0 (4.62)

Notes: [b]Range.

[c]Mean.

Mode* was determined using the eighty-percent criterion test described in Chapter II.

TABLE 6--Continued

Factor	Measurement Level	Descriptive Statistic	Statistical Value by Subgroup: ITMP Participant	Statistical Value by Subgroup: ITMP Nonparticipant
FY81				
DOD			40-55[b] (48.75)[c]	24-97(52.0)
F-16			5-7(6.0)	0.5-15.0(4.8)
FY82				
DOD			45-65(52.75)	24-97(57.6)
F-16			3.6-10.0(7.4)	0.3-15.0(4.96)
Investment Financing Sources	Nominal	Mode	"corporate pool"	"corporate pool"
Capital Investment Decision Rules	Ordinal	Mode*	ROI; Payback Period	NPV; ROI; Payback Period
Capital-Labor Mixture	Ordinal	Mode*	"uncertain"	"uncertain"

Notes: [b]Range.

[c]Mean.

Mode* was determined using the eighty-percent criterion test described in Chapter II.

TABLE 6--Continued

Factor	Measurement Level	Descriptive Statistic	Statistical Value by Subgroup: ITMP Participant	Statistical Value by Subgroup: ITMP Nonparticipant
Age of Capital Equipment[d]	Interval	Range(Mean)		
0- 5 yrs			10-25[b](18)[c]	10-50(27)
6-10 yrs			10-40(28)	0-50(16)
11-15 yrs			20-35(28)	0-35(18)
16-20 yrs			5-40(16)	0-30(15)
21-25 yrs			0-25(7)	0-15(4)
over 25 yrs			0-15(3)	0-53(20)
Average Age/Item of Capital Equipment			11.69 yrs	14.95 yrs
Labor Force				
Age (yrs)	Interval	Range(Mean)	35-43(37.6)	35-45(39.2)
Experience (yrs)	Interval	Range(Mean)	6-21(12.8)	6-22(13.4)
Need to Modernize	Ordinal	Mode*	"agree"	"agree"
Planning Period	Nominal	Mode	13-36 months	13-36 months; 37-60 months

Notes: [b]Range.

[c]Mean.

[d]As percent of total number of items.

Mode* was determined using the eighty-percent criterion test described in Chapter II.

factors, measurement levels, and statistical descriptors and values for both the ITMP participant and nonparticipant subgroups.

Market Environment

The factor "market environment" consisted of five subfactors (see Table 6) that were used to objectively assess and match the ITMP participant subgroup and nonparticipant subgroup with a theoretical economic marketplace.

Analysis revealed no difference between the two ITMP subgroups concerning the number of competitors (sellers) evident in either the commercial, Air Force, or F-16 marketplaces.

Evaluation of the information regarding the number of buyers indicated no observable difference in the number of DOD contractors that were buyers from the first-tier subcontractors in either the ITMP participant or the nonparticipant subgroups. However, the ITMP nonparticipant subgroup supplied a noticeably greater number of buyers (52) in the commercial marketplace.

Within each of the two subgroups, disagreement existed among the subcontractors concerning the availability of market information for decision making. Consequently, both the ITMP participant and nonparticipant subgroups were classified by the researchers as "uncertain" regarding the "knowledge of competition" factor.

The researchers observed that cross elasticity of demand existed within the ITMP nonparticipant subgroup. The finding was based on the "agreement" among the nonparticipants that the sales volume of the interviewees' primary product was influenced by a change in price of a competitor's similar product. In contrast, the ITMP participants' responses indicated an overall lack of "agreement" or "disagreement" regarding cross elasticity of demand. Therefore, the researchers classified the participant subgroup's response as "uncertain."

The two subgroups exhibited opposing attitudes concerning the ability to freely enter and/or exit the DOD marketplace. The ITMP participant subgroup felt that the opportunity to freely enter and/or exit the DOD marketplace existed. However, the ITMP nonparticipant subgroup's opinion was that DOD marketplace entry and/or exit was constrained. Specific nonparticipant subgroup comments were that the government "forces" defense contractors to maintain production of spare parts against the contractor's desires, that the government "pressures" contractors to remain in the DOD marketplace, and that there is a strong moral obligation to "stay with the program" regardless of financial success.

Perceived Market Environment

The ITMP participant subgroup's modal responses to "the type of economic marketplace in which business was conducted" were oligopoly for commercial, Air Force, and F-16 business. Regarding the conduct of commercial and Air Force business, the ITMP nonparticipant's modal responses were also oligopoly. However, with respect to F-16 business, the nonparticipant's modal response was monopolistic competition.

DOD Business

The DOD business factor revealed (in dollars) a F-16 first-tier subcontractor's DOD and F-16 business as a percent of total business for fiscal years 1980-1982. For all three years, the researchers observed no noticeable difference between the average percent of DOD and F-16 business for either the ITMP participant or nonparticipant subgroup. However, upon examining the range of both DOD and F-16 business as a percent of total business, the ITMP nonparticipant subgroup displayed greater variability.

Investment Financing Sources

The two ITMP subgroups of interest were asked to rank order eleven possible methods of financing capital investments according to the frequency of actual use. The researchers found that all the subcontractors in the ITMP participant subgroup relied on an external corporate

financing office (a "corporate pool") as the source of capital funds. With one exception, the entire ITMP non-participant subgroup also relied on a "corporate pool" for financing capital investments. However, four of the interviewed subcontractors within the participant subgroup were able to indicate the methods used most often by the higher corporate level to finance capital investment projects. The financing methods most frequently used included term loans with a maturity of greater than one year but less than fifteen years, issuance of common stock, and retained earnings. In the nonparticipant subgroup, only two subcontractors were able to provide information concerning corporate financing methods. One corporation exclusively used inventory financing. The other corporation used private loans secured through other companies with maturities greater than fifteen years, issuance of common stock, and retained earnings.

Capital Investment Decision Rules

A five-point Likert-type scale ranging from "never" to "always" was used to identify the decision criteria used by the interviewed first-tier subcontractors when evaluating possible capital investments. Three quantitative financial methods were found to be used with regularity. Both the ITMP participant and nonparticipant subgroups "always" evaluated potential capital investments using the return

on investment (ROI) method. Additionally, both subgroups used payback period as a decision criteria; the participant subgroup "often" used payback period, while the nonparticipant subgroup "always" used the payback period. Furthermore, the nonparticipant subgroup "always" used net present value (NPV) as a decision criteria.

Both the ITMP participant and nonparticipant subgroups indicated to the researchers that various other decision criteria, in addition to the previously identified "traditional" financial criteria, were used to evaluate potential capital investments (see Table 7).

TABLE 7

INVESTMENT DECISION CRITERIA USED BY ITMP SUBGROUPS

ITMP Participants	ITMP Nonparticipants
- product line expansion*	- equipment flexibility*
- equipment replacement*	- equipment reliability
- competitive requirements*	- equipment maintainability
- compliance with government safety* and pollution standards	- incremental income from new equipment
- improved product quality*	- maintenance and operating costs
- increased throughput	- energy efficiency
	- need to stay in business*

* Indicates criteria also used by the "consideration" and "oriented" subgroups.

Capital-Labor Mixture

The ITMP participant and nonparticipant subgroups were found to be "uncertain" based on the lack of consensus within the respective subgroups regarding the capital intensiveness of operations. Specific comments from the interviewed subcontractors in the nonparticipant subgroup included:

1. "The assembly operation is very labor intensive; we haven't found a way to mechanize a lot of tasks, however we are moving to capital intensive;" and

2. "As a company we are becoming more capital intensive; we are going to a large percentage of numerically controlled and automated equipment, modernizing through computer numerical control and direct numerical control."

One of the nonparticipant subcontractors stated that the volume of production was relatively small and therefore leads to labor-intensive production.

Age of Capital Equipment

The data provided by the participant and nonparticipant subcontractors indicated the age of capital equipment according to the percent of total items of equipment appearing in each of six mutually exclusive age categories. The mean for any one of the six categories represented the arithmetic mean calculated from the five subcontractors'

responses in each of the two ITMP subgroups. A weighted average using the midpoint of each of the six age categories was used to calculate a mean for each subgroup that represented the average age of an item of capital equipment. For the "over 25 years" age category, the subgroup's average total years in business was established as the maximum age of a piece of equipment, under the assumption that at least one piece of equipment was purchased at the time the subcontractor started business operations. The assumption enabled the researchers to determine an "over 25 years" age category midpoint. The resultant information indicated that the average age of an item of capital equipment in the ITMP participant subgroup was 11.69 years as compared to 14.95 years for the capital equipment found in the ITMP nonparticipant subgroup. Regarding the overall distribution of the percentage of capital equipment in each of the six age categories, the researchers only observed a noticeable difference in the "over 25 years" age category. The ITMP participant subgroup had an average of 3 percent of the total items of capital equipment older than 25 years, while the ITMP nonparticipant subgroup had an average of 20 percent of total items of capital equipment in the same age category. However, the researchers also observed from the data that two nonparticipant subcontractors had 50 percent or more of their capital

equipment that was older than 25 years, while the other three nonparticipant subcontractors had no capital equipment over 25 years.

As a statistical test of whether the participants' and nonparticipants' percentage of items of total equipment within each age category differed and whether the average age per item of capital equipment was different, the chi-square (χ^2) test for two independent samples and the Mann-Whitney U test were respectively used.

The χ^2 Test for Two Independent Samples. The χ^2 test provided a nonparametric statistical method for testing the null hypothesis (H_0) that there was no difference between the participant and nonparticipant subgroups' capital equipment age distribution. At the .05 significance level, there was sufficient evidence to reject the null hypothesis (see Appendix H), meaning that there was a significant difference between the participant and nonparticipant subgroups' percentage of total items of equipment in the six age categories.

Mann-Whitney U Test. The Mann-Whitney U test enabled the researchers to statistically determine if there was a difference between the average age of an item of capital equipment in the participant and nonparticipant subgroups. Under the null hypothesis that there was no difference in the average age of an item of participants'

and nonparticipants' capital equipment, the nonparametric Mann-Whitney U test provided a two-tailed probability of occurrence under H_0 equal to .548. Since the probability of occurrence, H_0 being true, was greater than the researchers' .05 significance level, the conclusion was that there was insufficient evidence to reject the null hypothesis (see Appendix I). The researchers' interpretation of the test results was that there was insufficient evidence to show a difference existed between the average age of an item of capital equipment in the participant and nonparticipant subgroups.

χ^2 Test Excluding the "Over 25 Years" Age Category. To test the "observed" difference existing in the previously discussed percentage of capital equipment in the "over 25 years" age category, a subsequent χ^2 test was performed excluding the over 25 years old category percentages. The χ^2 test results did not provide sufficient evidence to reject H_0 (see Appendix H) at the .05 significance level, meaning that there was no difference in the participants' and nonparticipants' age distribution of capital equipment when the "over 25 years" age category was excluded.

The researchers considered the two chi-square tests to be in agreement with the authors' observations regarding differences in the age distribution of the participant and nonparticipant subgroups' capital equipment.

Specifically, the researchers observed, noticeable difference in only the "over 25 years" age category appeared to significantly influence the results of the previously discussed chi-square tests. The chi-square test including all six age categories revealed a significant difference between the two subgroups' age distribution of capital equipment. However, when the "over 25 years" age category was excluded, the chi-square test indicated no significant difference between the two subgroups' age distribution of capital equipment.

Labor Force

There were no observable differences in either the average age or in the average number of years of experience of a production worker between the ITMP participant or nonparticipant subgroups.

Need to Modernize

Both ITMP subgroups of interest perceived the need to invest in modernized plants and equipment in order to increase the subcontractors' current dollar volume of DOD business. One specific comment received by the researchers from a nonparticipant subgroup subcontractor was that modernization was needed to lower the cost of production, and that if business is to grow, "You" have to be the best with continued technology improvements.

Planning Period

The most frequently used planning period for evaluating capital investment opportunities for both the ITMP participant and nonparticipant subgroups was 13 to 36 months. Additionally, the nonparticipant subgroup indicated that a planning period of 37 to 60 months was used with equal frequency. However, the data from both ITMP subgroups revealed noticeable variation in the different planning periods used by the subcontractors. In addition to the modal responses, the data from the participant subgroup indicated that periods of 0-12 months, 37-60 months, and 61 or more months were used, while a 0-12 months period was used by the nonparticipant subgroup.

Research Question No. 2

What are the most significant capital investment factors that could positively motivate a technology modernization decision?

First Primary Finding

To answer Research Question No. 2, the researchers analyzed the data collected from the four mutually exclusive ITMP subgroups (participants, nonparticipants, "consideration," and "oriented"). Each one of the total twenty contractors, which were equally divided among the four subgroups, ranked fourteen factors that could possibly influence a decision to undertake a capital investment to

modernize plant and equipment. Each subcontractor assigned a ranking of 1 (most significant) through a ranking of 14 (least significant) to the set of fourteen factors.

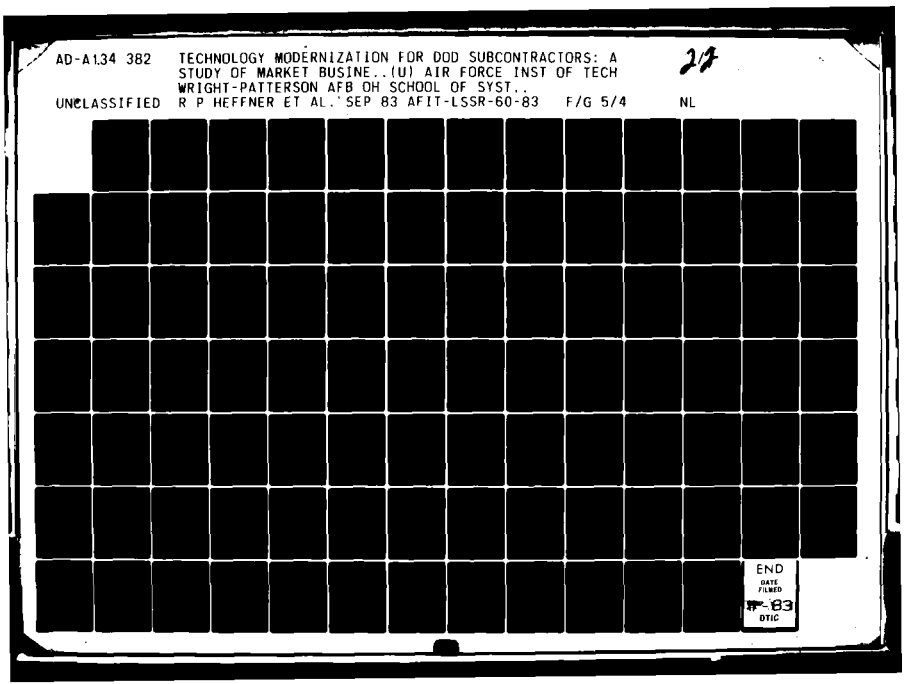
Kendall Coefficient of Concordance W. Each one of the four subgroups was analyzed individually using the nonparametric Kendall coefficient of concordance W (see Appendix D) previously discussed in Chapter II. The Kendall coefficient of concordance was used to determine if agreement existed within each one of the four ITMP subgroups; each subgroup consisted of five subcontractors' rankings of fourteen factors contained in the interview schedule. The four subgroups were then collectively analyzed to determine if agreement existed among the twenty sets of rankings within the entire sample (see Appendix E). The Kendall coefficient of concordance W tested the null hypothesis (H_0) that the twenty subcontractors' rankings were unrelated to each other, while the alternate hypothesis (H_a) was that the rankings were related.

When tested at the .05 significance level, the high value of W indicated that H_0 could be rejected, meaning that there was agreement among the five subcontractors' rankings within each subgroup. When the entire sample, consisting of twenty subcontractors' rankings, was tested at the .05 significance level, H_0 was rejected, meaning

that there was agreement among the rankings of the twenty subcontractors in the sample. Since the number of capital investment factors exceeded seven ($N > 7$), the chi-square distribution was used to test the probability of occurrence under H_0 of a value as large as the calculated W value (see Chapter II). Table 8 contains the critical and computed chi-square values and the test results used in determining the significance of the W value.

The high or significant W values were interpreted to mean that the subcontractors were in agreement on the ordering of the fourteen capital investment factors. Having a significant or high W value, the best estimate of the "true" ranking of the fourteen factors for the sample was determined using the order of the sum of the ranks, R_j (see Appendix E).

Friedman Two-Way Analysis of Variance by Ranks Test. The Friedman test, as discussed in the Research Methodology chapter, tested the null hypothesis (H_0) that there was no difference among the column sums of the four ITMP subgroups' rankings of the fourteen capital investment factors, meaning that the four subgroups did not agree on the rankings. The alternate hypothesis (H_a) was that there was a difference among the column sums of the four subgroups' rankings, meaning that the four subgroups did agree on the rankings. The Friedman test determined if the columns of ranks came from the same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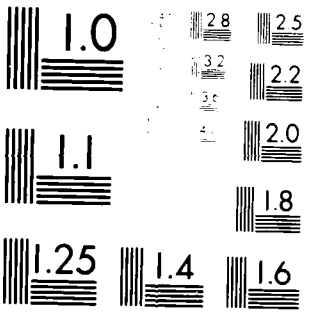
1.0
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6

TABLE 8

SIGNIFICANCE OF W TEST RESULTS

	ITMP Subgroup				Complete Sample
	Participant	Nonparticipant	"Consideration"	"Oriented"	
Degrees of Freedom	13	13	13	13	13
W value[a]	.44404	.37207	.35191	.51878	.27368
Critical χ^2 Value at the .05 Level of Significance	22.36	22.36	22.36	22.36	22.36
Computed χ^2 Value[b]	28.86	24.18	22.88	33.72	71.16
Probability of Occurrence Under H_0	.0069	.0295	.0431	.0013	.0000
Test Result	Reject H_0	Reject H_0	Reject H_0	Reject H_0	Reject H_0
Existence of Agreement	Yes	Yes	Yes	Yes	Yes

Notes: [a]A detailed discussion of calculating W is contained in Chapter II.

[b]$\chi^2 = k(N-1)W$.

population and, thus, whether the four ITMP subgroups agreed on the relative ordering of the fourteen capital investment factors.

Arranging the data in a table consisting of four rows representing the four ITMP subgroups and fourteen columns representing the fourteen investment factors (see Appendix F), the actual value of χ^2_{ranks} was computed to be 208.82122. The null hypothesis was tested against a critical chi-square value of 22.36 at the .05 significance level for 13 degrees of freedom. The probability of occurrence of H_0 (no agreement between the four subgroups' rankings) was .0000001. Therefore, H_0 was rejected, meaning that the four ITMP subgroups did agree on the rankings for the fourteen capital investment factors. Accordingly, it was possible to apply the sample's preferential ordinal ranking of the fourteen capital investment factors to the target population consisting of first-tier subcontractors.

Second Primary Finding

The special application of the Kendall coefficient of concordance W (21:239) allowed the researchers to obtain a preferential ordering of the fourteen capital investment factors. Using the previously discussed "eighty-percent criteria" test (see Chapter II) for measuring the validity of the twenty subcontractors' rankings, the capital investment factors that were "most significant" in influencing

a subcontractor's decision to modernize plant and equipment were identified. The capital investment factors were subsequently incorporated into recommendations for a set of investment incentives that should be offered to subcontractors as part of a comprehensive DOD program to improve productivity throughout the subcontractor level of the defense industry.

The four "most significant" capital investment factors, as determined by the twenty subcontractors in the sample, were providing a better quality product, achieving a minimum return on investment through a negotiated shared savings ratio, government indemnification in the event of a program's cancellation, and increased use of multiyear contracting.

Considering the four capital investment factors listed above, eighteen of the twenty subcontractors in the sample "agreed" that the opportunity to provide a better quality product would have a positive influence on a decision to undertake a capital investment to modernize plant and equipment. Similarly, there was agreement by sixteen subcontractors that achieving a minimum ROI through shared savings, nineteen subcontractors that government indemnification in the event of a program's cancellation, and sixteen subcontractors that the increased use of multiyear contracting would all have a positive influence on a capital investment decision to modernize plant and equipment.

Table 9 summarizes the ranking of the fourteen capital investment factors and the degree of agreement among the twenty first-tier subcontractors.

Summary of Primary Findings

The primary finding for Research Question No. 1 was that there were no significant observable differences in the data collected on the ITMP participant and nonparticipant subgroups in terms of economic, business, and financial characteristics. However, the researchers did observe noticeable variation within both of the ITMP subgroups regarding the length of the planning period used for evaluating capital investments.

The findings for Research Question No. 2 centered on the agreement among the twenty subcontractors in the sample on the ordinal ranking of the fourteen capital investment factors. The information revealed the capital investment factors agreed to by at least 80 percent of the sample as being a positive influence on a capital investment decision to modernize plant and equipment.

Corollary Findings

The research focused on collecting and analyzing data to determine whether there were any characteristics that differentiated the subcontractors participating in the ITMP and the subcontractors that elected not to participate in the F-16 ITMP. Additionally, the research

TABLE 9

RANKING OF CAPITAL INVESTMENT FACTORS AND DEGREE OF AGREEMENT AMONG SUBCONTRACTORS

Capital Investment Factor	Factor Ranking	Number of Subcontractors by ITMP Subgroup in Agreement on a Factor's Positive Influence on a Capital Investment Decision				No. of Subcontractors in Agreement	No. of Subgroups in Agreement
		Participant	Nonparticipant	"Consideration"	"Oriented"		
Providing a better quality product	1	5	5	4	4	18	4
Achieving a minimum ROI through shared savings	2	5	3	5	3	16	2
Accelerated depreciation	3	4	3	4	4	15	3
Government indemnification	4	5	5	4	5	19	4
Multiyear contracts	5	5	2	5	4	16	3
Partial government funding	6	4	4	2	3	13	2
Allowable interest cost	7	4	4	3	4	15	3
Tech Mod in source selection	8	4	3	3	3	13	1

TABLE 9--Continued

Capital Investment Factor	Factor Ranking	Number of Subcontractors by ITMP Subgroup in Agreement on a Factor's Positive Influence on a Capital Investment Decision				No. of Subcontractors in Agreement	No. of Subgroups in Agreement
		Participant	Nonparticipant	"Consideration"	"Oriented"		
Increased use of award fees	9	3	2	3	2	10	0
Shared savings on all follow-on contracts	10	5	2	2	3	12	1
Government loans	11	2	2	1	2	7	0
Shared savings on all existing contracts	12	3	3	3	2	11	0
Reduced number of Tech Mod reports	13	2	1	1	3	7	0
Retraining workers with government funds	14	1	2	1	2	6	0

effort attempted to identify the capital investment factors considered most significant towards influencing a subcontractor's decision to modernize plant and equipment.

The primary findings presented in the preceding sections of the chapter were the basis for answering Research Questions No. 1 and No. 2. The corollary findings that follow were obtained from the data collected during the interviews conducted during Phase I of the research, specifically, the interpretation of "comments" provided by the respondents and analysis of interview questions not discussed in the primary findings. The researchers considered that the corollary findings provided a more complete description of the sample's market, business, financial, and capital investment factors. Therefore, the corollary findings provided additional support for the researchers' conclusions and for the researchers' recommendations for investment incentives.

First Corollary Finding

Four capital investment factors were identified as "most significant" in the primary findings for Research Question No. 2. Although no other capital investment factors met the established eighty-percent criteria test for being "most significant," the researchers considered agreement by three of the four ITMP subgroups on any one factor as significant. Analyzing the remaining ten capital

investment factors, the researchers noted that only "accelerated depreciation" and "interest as an allowable cost" were agreed upon by three of the four ITMP subgroups. Furthermore, the information in Table 9 showed that fifteen out of twenty subcontractors agreed on the positive influence of accelerated depreciation and allowable interest costs on a capital investment decision to modernize plant and equipment. Consequently, the researchers included accelerated depreciation and allowable interest costs with the previously discussed "most significant" capital investment factors.

Second Corollary Finding

Analysis of the capital investment decision-making data revealed a consensus among all four ITMP subgroups regarding the degree of corporate financial control over the subcontractors' capital investment decision authority. All four subgroups required external corporate approval of capital investments for plant and equipment, although various corporate approval dollar thresholds among the four subgroups existed. The participant subgroup required external corporate approval for all capital investments, while the nonparticipant and "consideration" subgroups could commit $50,000 without external corporate approval. Finally, the "oriented" subgroup could make a capital

investment of $100,000 without obtaining external corporate approval.

Regarding the criteria used to make capital investment decisions, the "consideration" subgroup "always" used net present value and payback period and "often" used return on investment (ROI), while the "oriented" subgroup "often" used ROI and payback period. Additionally, both the "consideration" and "oriented" subgroups utilized qualitative factors similar to those qualitative factors considered by the participants and nonparticipants (see Table 7 on page 71).

Third Corollary Finding

The third corollary finding resulted from the researchers' subjective interpretation of the comments received from the sampled subcontractors during the course of the personal interviews. This finding addresses several major subcontractors' concerns regarding the overall issue of technology modernization.

First, there was a consensus within the sample that technology modernization is needed. Among the specific reasons for technology modernization indicated by the subcontractors were maintaining a "competitive edge," prompting top management to perform long-term strategic production planning, and providing long-term investment

alternatives to today's "band-aid" equipment replacement policies.

Second, the subcontractors indicated a definite need for technology modernization information to be made available to subcontractor middle and top-level management and DOD personnel involved in the defense acquisition process. Specifically, the subcontractors' comments focused on developing education programs as a means of building credibility and trust between the government and the contractor. Furthermore, the researchers found that the subcontractors desired more information regarding the "mechanics" of the ITMP and procedures for becoming involved in the Tech Mod program. The comments received from the subcontractors also revealed the necessity of educating the DOD acquisition community on the unique provisions and incentives that are part of the present Tech Mod program.

Directly related to the DOD acquisition workforce, the subcontractors expressed concern over a "cast of players" that changes too rapidly to provide stability to a long-term program such as Tech Mod. The subcontractors' opinions were that the current DOD practice of reassigning people approximately every three years worked to perpetuate short-term personal and program goals and adversely affected the development of the "mutual trust" and

"willingness" necessary to secure a contractor's commitment to capital investments.

Fourth was the subcontractors' admittance to the researchers that the subcontractors "did not really know" the exact age distribution of the capital equipment in their facilities (see Appendix B, question 20).

Finally, underlying all the subcontractors' comments was the concern over the uncertainty associated with annual defense procurement funding. Specific remedies to reduce the uncertainty, as supplied by the subcontractors, included multiyear procurement, indemnification, and the necessity of achieving some form of payback on investment in approximately two years.

Tertiary Findings

The data analysis resulted in accompanying information that the researchers considered contributory to fully understanding the characteristics of F-16 first-tier defense subcontractors. Therefore, the researchers decided that all findings relevant to the study of subcontractor technology modernization warranted reporting (see Appendix G). The tertiary findings included:

1. With the exception of the participant subgroup which was "uncertain," the sample "agreed" that production workers were capable of adapting to an automated production process.

2. The predominant comment received from the subcontractors concerning the age of production workers was that there was a high concentration of production workers in both the "young" and "old" age categories. The data revealed the average age of a production worker to be approximately in the "late-thirties" for all four subgroups.

3. There were no observable differences among the four ITMP subgroups' average age per item of capital equipment, nor did the results of the Kruskal-Wallis test (see Appendix J) indicate a difference among the four subgroups' average age per item of capital equipment.

4. The "consideration" and "oriented" subgroups both agreed on the need to modernize plant and equipment in order to increase the volume of DOD business.

5. Both the "consideration" and "oriented" subgroups used a 13-36 month planning period.

6. A"multi-service" link was evident among all twenty F-16 first-tier subcontractors. In addition to all twenty subcontractors supplying other Air Force programs, nineteen subcontractors supplied products to Navy programs, and fifteen subcontractors supplied products to Army programs.

7. Both the "consideration" and "oriented" subgroups indicated a few number of sellers (competitors) for commercial, Air Force, and F-16 business and were "uncertain"

regarding the knowledge of competition and the freedom to enter and/or exit the DOD marketplace.

8. The "consideration" and "oriented" subgroups' subjective assessments of the Air Force marketplace were perfectly competitive and oligopolistic respectively.

Summary

This chapter contained the researchers' primary, corollary, and tertiary findings. The primary findings directly addressed Research Questions No. 1 and No. 2 and were the basis for the researchers' conclusions and recommendations. Following the primary findings, the corollary findings contained information resulting from the analysis of the entire sample's data and provided additional support for the study's conclusions and recommendations. Finally, the researchers' tertiary findings presented information not discussed in any previous findings in order to more completely describe the sample of F-16 first-tier subcontractors. The next chapter discusses the conclusions based on the research findings and contains the researchers' recommendations for investment incentives.

CHAPTER IV

CONCLUSIONS AND RECOMMENDATIONS

Summary of Research Methodology

The research objectives discussed in the first chapter were: (1) to determine if any significant difference existed between the Industrial Technology Modernization Program (ITMP) participant and nonparticipant subgroups (see Figure 4 on page 26), and (2) to develop a set of investment incentives that should be used by the DOD to improve productivity throughout the defense subcontractor level.

The research methodology consisted of a field research phase (Phase I), an analysis and identification phase (Phase II), and a recommendations and evaluation phase (Phase III).

During Phase I, the researchers collected data from a random sample of twenty F-16 first-tier subcontractors (see Figure 4) using a standardized interview schedule in a field environment. The data collected during the field research phase became the input for the data analysis conducted by the researchers during Phase II of the research effort.

Data analysis conducted during the analysis and identification phase relied on descriptive and nonparametric statistical methods to provide the information necessary to answer Research Questions No. 1 and No. 2. The use of descriptive statistics was designed to answer Research Question No. 1--to characterize and determine if the participant and nonparticipant subgroups, each consisting of five F-16 first-tier subcontractors, significantly differed with regard to certain market, business, financial, and capital investment factors. To answer Research Question No. 2, the researchers selected the nonparametric Kendall coefficient of concordance W, the Friedman two-way analysis of variance by ranks test, and designed an eighty-percent criteria test to determine which capital investment factors were considered "most significant" by the sample. The results of Phase II provided the information used by the researchers to develop a set of investment incentives to motivate increased subcontractor Tech Mod participation. The recommendations formulated during Phase III were subsequently evaluated by several technology modernization "experts," thus completely answering Research Question No. 3 and fulfilling the research objectives. This chapter contains the researchers' conclusions and recommendations for investment incentives.

The researchers' specific answers to Research Questions No. 1 and No. 2 are contained in a general

response to each question. Immediately following the general response to each research question is a primary conclusion that is based specifically on the researchers' assessment of the primary findings related directly to a research question. Following Research Question No. 2's primary conclusion, corollary conclusions are presented. The corollary conclusions are supported by primary, corollary, and tertiary findings and are presented to assist in further understanding the interrelationships of the business, financial, and capital investment factors considered in a subcontractor's Tech Mod decision. Furthermore, the corollary conclusions provide additional support for the researchers' recommendations regarding the investment incentives, which integrated all the information obtained from the sample.

Research Question No. 1

Are significant differences evident in the market, business, and financial factors that describe the first-tier subcontractors currently participating in the F-16 ITMP from the nonparticipating subcontractors?

General Response

Differences were found between the ITMP participant and nonparticipant subgroups. However, the differences did not constitute sufficient evidence for the researchers to state that the two subgroups significantly

differed with respect to the market, business, and financial factors discussed in Chapter II.

Primary Conclusion

The researchers concluded that there were no specific market, business, or financial factors, or a combination of factors, that could be used to differentiate Tech Mod program participants from nonparticipants.

Research Question No. 2

What are the most significant capital investment factors that could positively influence a subcontractor's technology modernization decision?

General Response

The capital investment factors identified as "most significant" by the sample's twenty subcontractors were: providing a better quality product, achieving a guaranteed minimum return on investment through negotiated shared savings, government indemnification, multiyear contracting, accelerated depreciation, and allowable interest costs.

Primary Conclusion

The researchers concluded that the subcontractors place a high priority on maintaining/improving the reputation for producing quality products. Furthermore, three other predominant concerns influenced the twenty

subcontractors' selections of the remaining five "most significant" capital investment factors. The concerns were greater risk assumption by the government, reduced uncertainty in the defense procurement process, and improved short-term cash inflows on modernization capital investments.

Corollary Conclusions

The following section contains the researchers' corollary conclusions which provided a more in-depth description of the entire sample of the twenty F-16 first-tier subcontractors. The corollary conclusions were based on the researchers' interpretation of the importance of the study's findings in achieving the two research objectives--developing a set of investment incentives the DOD should use in a comprehensive subcontractor Tech Mod effort and characterizing F-16 first-tier subcontractors.

First Corollary Conclusion

The findings concerning capital investment decision criteria and planning periods indicated that all four ITMP subgroups relied on return on investment, payback period, and a 13-36 month planning period when evaluating capital investments. The researchers concluded that, regardless of a commitment to modernize under Tech Mod, subcontractors generally ignored the time value of money over the long term and were more concerned with a rapid inflow of

capital in the short term. Additionally, the researchers concluded that capital investment decisions were influenced in the four subgroups by qualitative considerations such as equipment flexibility, equipment replacement, equipment maintainability, and competitive requirements.

Second Corollary Conclusion

Unless the subcontractor was an autonomous business entity, the final approval to undertake a technology modernization investment existed at a higher corporate level. All four of the ITMP subgroups relied on external corporate financing offices to approve and provide funding for subcontractors' capital investments. Directly related was the conclusion that internal sources, specifically financing with retained earnings and common stock, were frequently used by both the participant and nonparticipant subgroups.

Third Corollary Conclusion

Based on the comments received from all four ITMP subgroups regarding the age of capital equipment, the researchers concluded that the subcontractors did not place sufficient emphasis on the need for accurate age data on existing equipment. The researchers further concluded that the subcontractors were not fully considering the overall age distribution of capital equipment in a technology modernization analysis.

Fourth Corollary Conclusion

Subcontractors realized the importance of modernization and were generally receptive to the Tech Mod concept as one means of modernizing plant and equipment. The researchers concluded that Tech Mod's "top-down" factory analysis orientation required the subcontractors to evaluate production modernization from a long-term "macro" perspective, in contrast to some subcontractors' existing "band-aid" equipment replacement policies.

Fifth Corollary Conclusion

An inadequate amount of Tech Mod information and education was available to support DOD technology modernization initiatives. The researchers further concluded that both DOD procurement personnel and subcontractor management had not received the necessary amount of information needed to foster a "win-win" relationship. The lack of understanding of Tech Mod's unique contractual provisions has hindered program acceptance and commitment by subcontractors' middle and top-level management and has adversely affected the working relationship between the government and the subcontractors. Consequently, many subcontractors were reluctant to accept the government as a "business partner" in a Tech Mod program.

Sixth Corollary Conclusion

DOD's present assignment system does not recognize the importance of a stabilized workforce in defense procurement. The short-term "business-face" to subcontractors caused by reassignments approximately every three years has contributed to the deterioration of the long-term business relationships between the government and subcontractors. The resulting low level of "mutual trust" undermines the "business partner" relationship upon which Tech Mod is based.

Seventh Corollary Conclusion

Although the four subgroups' perceptions of the type of economic market varied considerably, two economic market indicators, the number of competitors (sellers) and the knowledge of the competition, were dominant in the researchers' overall conclusion that all four subgroups operated in an oligopolistic marketplace for F-16 and Air Force business. Consequently, the DOD procurement policies based on a perceived high level of competition in the marketplace do not recognize the present low level of competition that actually exists in the market. The resulting conclusion is that DOD business is concentrated among relatively few firms and that the opportunity for future increases in the number of procurement sources is limited.

Recommendations

The researchers' recommendations were specifically intended to provide a set of investment incentives that the DOD should offer as part of a comprehensive subcontractor Tech Mod program. The recommendations were based on the capital investment factors identified by the sample as being most significant towards influencing a technology modernization decision and the researchers' primary and corollary conclusions discussed in the preceding section of this chapter. The researchers' recommendations were intended to provide the DOD with a set of investment incentives from which the appropriate incentives would be selected depending on the circumstances. Thus, the investment incentives would become flexible "contractual tools" that should be tailored to each different Tech Mod situation and each individual subcontractor's needs.

Recommendation for Acknowledging Improved Product Quality

Three potential areas are available for recognizing the importance that subcontractors place on providing a better quality product. First, source selection teams should allocate an increased percentage weighting to quality when developing source selection evaluation criteria. Second, performance fees should be used to reward contractor technology modernizations that directly improve product quality. The performance fees should be based on

measurable quality characteristics, such as reduced scrap/rework percentages and increased product reliability. Finally, the DOD should establish a "Subcontractor Technology Improvement Recognition (STIR)" program that acknowledges enhanced product quality gained through technology modernization. The three recommendations should communicate to subcontractors the importance that the DOD places on acquiring quality products. At the same time, the recommendations provide subcontractors with tangible incentives to improve product quality through increased capital investments for technology modernization.

Recommendation for Shared Savings Ratio

The current method of guaranteeing the subcontractor a minimum rate of return on technology modernization investments through a negotiated savings sharing ratio should be continued. However, the subcontractors require additional information regarding the process for determining and negotiating the savings sharing agreement between the government and the subcontractor. As a specific recommendation that could be implemented in the near term by the DOD, a "lessons learned" program should be established to increase the flow of information between the office administering the particular Tech Mod programs and the subcontractors. The "lessons learned" program should address the general difficulties encountered by the

subcontractors who are contractually involved with a DOD Tech Mod program (e.g., F-16 or B-1B). A specific means of facilitating the crossfeed of Tech Mod "lessons learned" could include a symposium hosted by the DOD Tech Mod program administration office, involving presentations from the subcontractors involved with an on-going Tech Mod program. Furthermore, the symposium concept should be expanded across multiple programs and among the military services to improve the crossfeed of information and "lessons learned" among the numerous existing Tech Mod programs. The researchers emphasize that the symposium concept should be conducted at regular intervals (i.e., bi-monthly or quarterly) to provide useful real-time information that can be used by both the DOD and subcontractors to achieve a workable savings sharing agreement.

Recommendation for Making Interest an Allowable Cost

The Defense Acquisition Regulation (DAR) presently identifies interest as an unallowable cost. The researchers' recommendation is that the DAR be amended to make interest on borrowed capital specifically used to fund Tech Mod investments or other productivity enhancement initiatives an allowable cost. For Tech Mod investments, the external source of funding and the amortized interest schedule should be made an attachment to the contractor's Capital Acquisition Request (CAR).

Adoption of the recommendation to make interest an allowable cost would be consistent with the income tax provisions that recognize the cost of using debt to operate a business. Pertaining directly to incentivizing Tech Mod investments, the recommendations should increase a contractor's short-term cash inflows, recognize interest as a cost of commitment to modernization, and provide traceability of interest costs.

Recommendation for Accelerated Depreciation Allowances

Presently, Cost Accounting Standard (CAS) 409 requires that a tangible capital asset's depreciable cost be the asset's acquisition cost less the residual value. One recommendation that recognizes the subcontractors' planning period (13-36 months) is to redefine the depreciable cost of a tangible capital asset as the future value of the asset's acquisition cost computed for the third year following acquisition using the prevailing DOD discount factor. A second recommendation is that the Contract Administration Organizations (CAOs) be urged to allow greater flexibility in the interpretation of the existing CAS 409 provision for use of accelerated depreciation methods by government contractors involved in technology modernization programs. Adoption of the above two recommendations could improve a contractor's cash flows and return on investments for new equipment, additional capital

would become available for equipment replacement, and technology modernization would be incentivized. Furthermore, the basic cost accounting principle of assigning the cost of an asset to the accounting period in which it is used is preserved.

A final recommendation concerning accelerated depreciation is to amend the Economic Recovery Tax Act (ERTA) of 1981 to allow the use of double-declining balance (DDB) depreciation only for Tech Mod investments. The DDB depreciation method would replace the existing 150 percent declining balance presently allowed under ERTA. At the same time, the option to switch from DDB to straight-line depreciation at the optimal point should be maintained. This recommendation would provide the contractor increased after-tax cash flows in the early years of an asset's life, thereby further incentivizing the contractor to invest in modern equipment.

Recommendation for Government Indemnification

A clause should be incorporated into the DAR that would provide for the subcontractor to recover a negotiated percentage of a Tech Mod investment. The clause would be exercised only in the event that program cancellation(s) prevent the use of the negotiated savings sharing methods by the subcontractor to achieve a "guaranteed" minimum return on investment. DAR 1-315 and 3-815 presently

contain a "Capital Investment Incentive Clause" that allows the government to buy back severable capital equipment. The researchers recommend that a similar "Technology Modernization Indemnification Clause" be developed that would allow the government to pay the subcontractor a negotiated cash-percentage of the initial Tech Mod investment when program cancellations would not allow the subcontractor to fully recover the negotiated minimum return on investment.

Incorporation of the recommended indemnification clause would recognize the uncertainty of annual DOD business at the subcontractor level and provide a means of risk aversion for the subcontractor and risk assumption by the government to further encourage Tech Mod participation.

Recommendation for Increased Use of Multiyear Procurement

The DOD should continue to pursue the application of multiyear contracting at the prime contractor level to the maximum practical extent. More importantly, emphasis should be placed on the prime contractor's "flow down" of the contractual benefits of multiyear procurement to the first-tier subcontractors. The "flow down" of multiyear benefits should serve to reduce the uncertainty associated with subcontractor DOD procurements, provide increased opportunity for long-term modernization planning, and

further incentivize a subcontractor's decision to commit capital for facility modernization.

Component breakout is a second area that the researchers recommend multiyear procurement application be used to incentivize increased Tech Mod participation. Specifically, components that are "broken-out" and managed by a single program office and which are used across multiple programs (e.g., ACES II ejection seat) should be placed on multiyear contracts. Furthermore, items that are identified for component breakout as part of an on-going multiyear acquisition program (e.g., F-16) should be awarded on a multiyear basis. In both cases, the researchers recognize that competition will possibly be reduced for that particular item. However, the multiyear benefits that include reduced uncertainty for the contractor and the accompanying potential incentive for investing in capital equipment, in the researchers' opinion, outweigh the reduced competition in an already identified oligopolistic marketplace.

Recommendation for Incentive Fee Use

The recommendation is to replace award fees as Tech Mod contractual incentives with performance fees, whenever it is possible to establish objective evaluation criteria. The subjectivity of award fees was recognized by the researchers as a disincentive to subcontractor

Tech Mod participation. The subcontractor should be objectively evaluated against a set of cost, performance, schedule, and quality criteria, agreed upon by the government and the contractor during the Tech Mod "business deal" formulation. The objective determination of a performance fee should be accomplished by a DOD organization, educated in technology modernization, that is separated from the program manager. The recommendation should help to remove the observed perception that contractors' technology modernization efforts are greatly affected by a subjective assessment from short-term, system program-oriented DOD managers.

Recommendation for Corporate Level Tech Mod Involvement

It is recommended that as part of any initial Tech Mod communication with subcontractors that the Tech Mod program manager accurately identify the appropriate corporate level that controls the allocation of funds to the respective subcontractor (corporate division). A representative from the identified corporate controlling level should be included in all subsequent Tech Mod discussions with the individual subcontractors. This should increase the awareness and knowledge of the corporate decision makers that ultimately will evaluate subcontractor proposed Tech Mod capital investments. Additionally, the recommendation should assist in obtaining a firm management commitment to

the elements of technology modernization from the corporate through the division (subcontractor) level.

Recommendation for Education of the DOD Acquisition Community

The researchers recommend that the various DOD acquisition organizations (i.e., buying activities, contract administration organizations, and Defense Contract Audit Agency) be educated on the unique Tech Mod contractual provisions and incentives. The education of buying office, program management, and contract administration personnel should facilitate the "win-win" working relationship between the government and the subcontractor that is essential to Tech Mod's "business partner" philosophy.

Recommendation for DOD Workforce Stability

The DOD should change the reassignment guidelines for acquisition managers at both the buying offices and at the contract administration organizations. The acquisition managers should be assigned for a minimum of five years with an option to extend the assignment for a sixth year. The result should be a stabilization of the DOD's top and middle-level management, which would improve the working relationship between defense contractors and the government. The recommendation is intended to overcome the observed subcontractor opinion that long-term commitments to technology modernization are impeded by the short-term personal

goal orientation perpetuated by the current DOD assignment process. In turn, the result should be the establishment of increased "mutual trust" between the government and the contractor, that has been identified as essential, but lacking, in Tech Mod programs to date. The researchers emphasize that this recommendation must be accompanied by the DOD's recognition of the importance of long-term oriented acquisition managers. Furthermore, the DOD must reevaluate current career and promotion progression policy to assure that DOD acquisition managers' careers are not adversely affected by "extended" acquisition program assignments.

Field Evaluation of Recommendations

The researchers presented the aforementioned nine recommendations to a group of Tech Mod "experts" representing the Air Force Systems Command Aerospace Industrial Modernization (AIM) office, the Aeronautical Systems Division Directorate of Manufacturing and Quality Assurance (ASD/PMD), and the Air Force Wright Aeronautical Laboratory's Materials Laboratory Manufacturing Technology Division (AFWAL/MLT). The feedback received by the researchers from the "experts" indicated that the recommendations had practical application for current and future DOD technology modernization initiatives. Specifically, the "experts" strongly agreed that the researchers'

recommendations for corporate level Tech Mod involvement and education of the acquisition community were necessary and should be integrated immediately into existing Tech Mod programs.

Implications of the Research

The authors' research project in the area of subcontractor technology modernization was, to the researchers' knowledge, the first empirical study of subcontractors' market, business, financial, and capital investment characteristics. Consequently, the researchers created an initial data base that should be used as the basis for future research. More importantly, the researchers identified the capital investment factors that subcontractors viewed as most significant towards influencing technology modernization investments. The resulting recommendations from the research provided the DOD several means of incentivizing modernization investments that should be applied in the short term for existing Tech Mod programs. Furthermore, several of the researchers' recommendations require long-term government policy/regulation changes. Together, the study's recommendations provide a framework for structuring future DOD technology modernization/productivity enhancement initiatives at the subcontractor level.

Recommendations for Future Research

The researchers recommend that future research efforts focus on the following defense procurement areas:

1. A study should be conducted on the impact of current DOD profit policy on DOD technology modernization efforts. Specifically, how do the current DOD policies for maximum obtainable profit affect defense contractors' decisions to modernize plant and equipment? The research should examine both fixed-price and cost-reimbursement type contracts.

2. A follow-on study should examine the practicality of establishing a method to recognize the independent modernization efforts now being implemented by some defense subcontractors. One particular area of research should address the source selection process and weighting of modernization initiatives.

3. A replication of this study should investigate the market, business, financial, and capital investment characteristics that exist among second, third, and lower-tier subcontractors.

4. A future study should compare the subcontractors involved in various DOD Tech Mod programs. Specifically, the research should compare and identify if any significant differences exist among the subcontractors participating in one particular military service's Tech Mod

programs (i.e., F-16, B-1B, AMRAAM) or among multiple-services' programs (i.e., Air Force, Navy, or Army).

5. A cost-benefit analysis should focus on the researchers' recommendations for accelerated depreciation allowances and allowable interest costs. The additional costs to the government involved with implementing the two recommendations should be evaluated against the potential cost savings and improved product quality made possible by technology modernizations.

Final Observations

The researchers consider the results of the study of subcontractor decision making for technology modernization as providing invaluable insight into the characteristics and capital investment motivators existing at the first-tier subcontractor level. Directly addressing the two research objectives of the study, the researchers regard the data collected, conclusions, and resulting recommendations to motivate increased subcontractor Tech Mod participation as an accurate reflection of the defense subcontractors' market, business, financial, and capital investment concerns. The researchers acknowledge that implementation of some of the aforementioned recommendations will entail DOD procurement regulation changes and, in some instances, will require Congressional legislative action. However, the researchers strongly believe that

a consolidated and comprehensive DOD Tech Mod effort is necessary, if the subcontractor base of the defense industry is to remain responsive to defense surge and mobilization demands. Furthermore, the researchers view technology modernization as a viable and practical means of improving productivity throughout the entire subcontractor level of the defense industry. Besides the potential cost savings and improved product quality made available to defense acquisition programs, modernization and improved productivity will strengthen the industrial capability of the United States and improve its competitive position among the industrialized nations of the world.

APPENDICES

APPENDIX A

THE FOURTEEN CAPITAL INVESTMENT FACTORS

The following factors were identified by the researchers as possibly influencing a decision to undertake a capital investment to modernize plant and equipment used for DOD business.

A. Achieving a guaranteed minimum rate of return on Tech Mod investment(s), through shared savings.

B. The availability of government loans at less than the prime interest rate--only for Tech Mod Investments. Specify number of points below prime rate: ____

C. Partial government funding of Tech Mod investment(s). Indicate the percentage of government funding: ____

D. Changing the Defense Acquisition Regulation (DAR) to make interest costs incurred with Tech Mod investment(s) an allowable cost.

E. Allowing greater accelerated depreciation of Tech Mod plant and equipment.

F. Increased use of multiyear contracting.

G. Government funding for the retraining of workers displaced by Tech Mod projects.

H. Reduction in the number of required Tech Mod reports to the government.

I. Applying the negotiated savings sharing ratio to all existing government contracts for currently produced products.

J. Increased use of award fees for Tech Mod investments.

K. The opportunity to provide a better quality product.

L. Including Tech Mod efforts as a source selection criteria.

M. Achieving a negotiated payback on Tech Mod investment(s) through government indemnification, in the event of a program's cancellation.

N. Applying the negotiated savings sharing ratio to all follow-on government contracts for currently produced products.

APPENDIX B

TECHNOLOGY MODERNIZATION INTERVIEW SCHEDULE

TECHNOLOGY MODERNIZATION

INTERVIEW SCHEDULE

May-June 1983

For use only by Major John Weimer and Captain Richard Heffner in the course of thesis research in partial fulfillment of Graduate requirements at the Air Force Institute of Technology, School of Systems and Logistics.

TECHNOLOGY MODERNIZATION INTERVIEW SCHEDULE

SECTION I

INTERVIEWEE'S NAME: _____

INTERVIEWEE'S JOB TITLE: _____

NUMBER OF YEARS EMPLOYED BY: OVERALL CORPORATION: _____

GOVERNMENT BUSINESS DIVISION: _____

TECHNOLOGY MODERNIZATION OFFICE: _____

ALL OTHER GOVERNMENT CONTRACTORS: _____

ALL OTHER COMMERCIAL CONTRACTORS: _____

OTHER GOVERNMENT ORGANIZATIONS: _____

NAMES OF OTHER GOVERNMENT CONTRACTORS OR OTHER CORPORATE DIVISIONS EMPLOYED BY: _____

_____

_____

NAMES OF COMMERCIAL CONTRACTORS EMPLOYED BY: _____

_____

_____

NAMES OF GOVERNMENT ORGANIZATIONS EMPLOYED BY: _____

_____

_____

DATE OF INTERVIEW: _____

CORPORATION NAME: _____

_____

CORPORATION DIVISION: _____

_____

PARENT CORPORATION: _____

_____

NUMBER OF YEARS COMPANY (OR DIVISION) HAS BEEN IN BUSINESS: _____

NUMBER OF YEARS COMPANY (OR DIVISION) HAS BEEN IN DOD BUSINESS: _____

NUMBER OF TOTAL EMPLOYEES: _____

NUMBER OF PRODUCTION EMPLOYEES: _____

COMPANY'S (OR DIVISION'S) PRIMARY PRODUCT:

For F-16 Program: _____

_____

For Other Air Force Programs: _____

_____

For Navy Programs: _____

_____

For Army Programs: _____

_____

For Commercial Programs: _____

_____

SECTION II

1. Number of companies your primary product is supplied to (commercial business):_____

2. Number of companies your primary product is supplied to (DOD business):_____

3. Number of companies that directly compete with your primary commercial product (circle the category):

   a. 0
   b. 1
   c. 2-5
   d. 6-15
   e. 16-25
   f. 26 or more

4. Number of companies that directly compete with your primary Air Force product (circle the category):

   a. 0
   b. 1
   c. 2-5
   d. 6-15
   e. 16-25
   f. 26 or more

5. Number of companies that directly compete with your primary F-16 product (circle the category):

   a. 0
   b. 1
   c. 2-5
   d. 6-15
   e. 16-25
   f. 26 or more

6. Using the provided marketplace definitions, and referencing your primary product, identify the market your company (or corporate division) operates in. (Place the appropriate letter from the definition page in the categories provided below):

   For F-16 business: _____

   For all Air Force business: _____

   For Commercial business: _____

DIRECTIONS FOR SECTION III

Please respond as accurately as possible. Respond to the following items according to the following example.

Response to Circle	Definition
1	If you strongly disagree with the statement
2	If you disagree with the statement
3	If you are uncertain (neither disagree nor agree) with the statement
4	If you agree with the statement
5	If you strongly agree with the statement

Example: If you are uncertain about a statement, completely circle number 3.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
1	2	(3)	4	5

SECTION III

7. Current and accurate market information concerning competitors who produce the same primary product as your company (or corporate division) is available for decision making.

	Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
F-16 Product:	1	2	3	4	5
Air Force Product:	1	2	3	4	5

Comments: _____

_____

_____

8. The sales volume (in terms of units) of your company's (or corporate division's) primary product changes when competitors change the price of similar product(s).

	Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
F-16 Product:	1	2	3	4	5
Air Force Product:	1	2	3	4	5

Comments: _____

_____

_____

9. Your company (or corporate division) has the opportunity to freely enter and exit the DOD subcontractor market based solely on business and/or financial decisions.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
1	2	3	4	5

Comments: _____

_____

_____

10. Using the provided definition of a capital intensive company, to what extent do you agree that your company is capital intensive?

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
1	2	3	4	5

Comments: _____

_____

_____

11. Generally, your company's (or corporate division's) production workers are capable of adapting to an automated or computer-aided production process.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
1	2	3	4	5

Comments: _____

_____

_____

12. In order to increase your company's (or corporate division's) current dollar volume of DOD business, additional investments in modernized plant and equipment are needed.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
1	2	3	4	5

Comments: _____

_____

_____

13. To what extent do you agree that the following 14 factors, when considered independently, would have a positive influence on your company's decision to undertake a capital investment to modernize plant and equipment.

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
1	2	3	4	5

Achieving a guaranteed minimum rate of return on Tech Mod investment(s), through shared savings.	1	2	3	4	5
The availability of government loans at less than the prime interest rate--only for Tech Mod investments. Specify number of points below prime rate: ____	1	2	3	4	5
Partial government funding of Tech Mod investment(s). Indicate the percentage of government funding: ____	1	2	3	4	5
Changing the Defense Acquisition Regulation (DAR) to make interest costs incurred with Tech Mod investment(s) an allowable cost.	1	2	3	4	5
Allowing greater accelerated depreciation of Tech Mod plant and equipment.	1	2	3	4	5
Increased use of multiyear contracting.	1	2	3	4	5
Government funding for the retraining of workers displaced by Tech Mod projects.	1	2	3	4	5
Reduction in the number of required Tech Mod reports to the government.	1	2	3	4	5

Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
1	2	3	4	5

Applying the negotiated savings sharing ratio to all existing government contracts for currently produced products.	1	2	3	4	5
Increased use of award fees for Tech Mod investments.	1	2	3	4	5
The opportunity to provide a better quality product.	1	2	3	4	5
Including Tech Mod efforts as a source selection criteria.	1	2	3	4	5
Achieving a negotiated payback on Tech Mod investment(s) through government indemnification in the event of a program's cancellation.	1	2	3	4	5
Applying the negotiated savings sharing ratio to all follow-on government contracts for currently produced products.	1	2	3	4	5

14. Your company uses the following decision criteria when evaluating potential capital investments (circle the most appropriate response).

	Never	Rarely	Sometimes	Often	Always
Net Present Value	1	2	3	4	5
Internal Rate of Return	1	2	3	4	5
Return on Investment	1	2	3	4	5
Payback Period	1	2	3	4	5
Other Criteria (specify)					
_____	1	2	3	4	5
_____	1	2	3	4	5
_____	1	2	3	4	5
_____	1	2	3	4	5

15. Referencing Question 14, what is the primary basis for your response (check the appropriate response)?

____ It is company (or corporate division) policy.

____ It is corporate (i.e., parent company) policy.

____ There is no standardized policy specifying investment decision criteria.

Comments: _____

_____

_____

SECTION IV

16. Your company's (or corporate division's) fiscal year is (circle the correct response):

    a. October - September

    b. January - December

    c. July - June

    d. Other (specify) _____

17. Using the response to Question 16, indicate your company's (or corporate division's) percent of total business during the following fiscal years, that was generated by:

	1980	1981	1982
All F-16 products	____	____	____
All DOD products	____	____	____

18. What is the average age of a production (i.e., factory or direct labor) worker in your company (or corporate division)?

    ____ years

19. How many years of experience does your average production worker have?

    ____ years

20. What percentage of your company's capital equipment could be categorized as being:

AGE OF EQUIPMENT	ALL CAPITAL EQUIPMENT	CAPITAL EQUIPMENT USED SOLELY FOR DOD BUSINESS
0-5 years old	_____	_____
6-10 years old	_____	_____
11-15 years old	_____	_____
16-20 years old	_____	_____
21-25 years old	_____	_____
More than 25 years old	_____	_____
TOTAL	100%	100%

Comments: _____

_____

_____

21. What planning period (in months) does your company (or corporate division) normally use when evaluating capital investment undertakings (circle the appropriate response)?

    a. 12 months or less
    b. 13 - 36 months
    c. 37 - 60 months
    d. 61 months or more

22. Do your company's (or corporate division's) capital investment decisions require external higher level approval (circle the response)?

    Yes No

    Comments: _____

    _____

    _____

23. If the response is yes to Question 22, the maximum capital investment that can be made without external approval is (circle the response):

    a. $1
    b. $50,000
    c. $100,000
    d. $300,000
    e. $500,000
    f. $1,000,000 or more

24. Rank order the following capital investment financing methods according to actual use by your company (or corporate division). (1 = most used; 11 = least used)

    ____ trade credit (accounts payable)
    ____ notes payable (from commercial banks)
    ____ commercial paper
    ____ accounts receivable
    ____ inventory financing
    ____ term loans (maturities greater than 1 year but less than 15 years)
    ____ Private placements (direct business loans with maturities greater than 15 years)
    ____ issuance of common stock
    ____ issuance of preferred stock
    ____ issuance of bonds
    ____ retained earnings

    Comments: _____

    _____

    _____

SECTION V

The following factors could possibly influence a decision to undertake a capital investment to modernize plant and equipment used for DOD business. Rank the factors from most significant (ranking of 1) to least significant (ranking of 14).

____ Achieving a guaranteed minimum rate of return on Tech Mod investment(s), through shared savings.

____ The availability of government loans at less than the prime interest rate--only for Tech Mod investments. Specify number of points below prime rate: ____

____ Partial government funding of Tech Mod investment(s). Indicate the percentage of government funding: ____

____ Changing the Defense Acquisition Regulation (DAR) to make interest costs incurred with Tech Mod investment(s) an allowable cost.

____ Allowing greater accelerated depreciation of Tech Mod plant and equipment.

____ Increased use of multiyear contracting.

____ Government funding for the retraining of workers displaced by Tech Mod projects.

____ Reduction in the number of required Tech Mod reports to the government.

____ Applying the negotiated savings sharing ratio to all existing government contracts for currently produced products.

____ Increased use of award fees for Tech Mod investments.

____ The opportunity to provide a better quality product.

____ Including Tech Mod efforts as a source selection criteria.

____ Achieving a negotiated payback on Tech Mod investment(s) through government indemnification, in the event of a program's cancellation.

____ Applying the negotiated savings sharing ratio to all follow-on government contracts for currently produced products.

OTHER COMMENTS CONCERNING
TECHNOLOGY MODERNIZATION

APPENDIX C

KEY DEFINITIONS OF INTERVIEW SCHEDULE TERMS

DEFINITIONS

For Questions 1 through 8:

Primary product for either F-16, DOD, or commercial business refers to that product previously indicated as primary by the respondent in Section I of this interview guide.

For Question 6:

a. Perfectly Competitive:

A perfectly competitive market is characterized by: a homogenous product; perfect information concerning competition and the conditions in the marketplace; many sellers of the product, meaning the business actions of any one company do not affect the going market price of th product; many buyers of the product, meaning that a buyer's total amount of purchases are so small that the buyer is unable to influence the product price; production resources that may be switched from one use to another readily; and no important restrictions on a firm's decision to enter or leave the market.

b. Monopolistic Competition:

Monopolistic competition is characterized by the existence of many sellers of products that are very similar (but not perfect substitutes for each other). The products are either actually differentiated, meaning they differ in terms of form, or composition but have the same function; or spurious (perceived) differentiated, resulting from advertising or promotion that causes the buyers to purchase a particular brand.

c. Oligopoly:

An oligopoly is characterized by a market with few suppliers; where each supplier has a significant amount of economic influence, but not enough influence to disregard the reactions of competitors. Product differentiation results from advertising, or levels of quality or service.

d. Duopoly:

A duopoly is a special case of an oligopoly in which there are only two sellers.

e. A monopoly is characterized by a market with one supplier of a unique product (there are no close substitutes for the product).

For Question 10:

A capital intensive company is a company that has a higher proportion of capital equipment costs compared to direct labor costs.

For Question 14:

Net Present Value: a discounted cash flow project evaluation method. All cash inflows and cash outflows are discounted at a minimum acceptable rate of return that has been decided upon by the company.

Internal Rate of Return: a discounted cash flow project evaluation method. The method determines the specific interest rate that discounts an investment's future cash inflows, so that the present value of those cash inflows exactly equals the cost of the investment.

Return on Investment: a method of evaluating capital investment decisions by computing a rate of return on an investment using accounting measures of net income. The formula is:

$$\text{Return on Investment} = \frac{\text{Annual Net Income from Investment}}{\text{Project Investment}}$$

Payback Period: a method of evaluating capital investment decisions that determines how long it takes for an investment to return the cost of the investment. The formula is:

$$\text{Payback Period} = \frac{\text{Initial Investment}}{\text{Annual Net Income from Investment}}$$

APPENDIX D

THE KENDALL COEFFICIENT OF CONCORDANCE TEST DATA FOR EACH ITMP SUBGROUPS' RANKING OF THE FOURTEEN CAPITAL INVESTMENT FACTORS

TABLE 10

ITMP PARTICIPANT SUBGROUP RANKINGS OF THE FOURTEEN CAPITAL INVESTMENT FACTORS

Participant Subcontractors	Capital Investment Factor Ranking													
	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	5	12	1	8	6	2	14	13	3	4	7	11	9	10
2	5	7	2	8	6	1	13	14	11	3	9	4	10	12
3	4	5	6	8	7	1	13	14	11	3	10	12	2	9
4	4	11	10	3	9	6	14	13	8	12	1	2	5	7
5	4	13	7	10	12	11	14	8	6	9	5	1	2	3
R_j	22	48	26	37	40	21	68	62	39	31	32	30	28	41
$R_j - \frac{\Sigma R_j}{N}$	-15.5	10.5	-11.5	-.5	2.5	-16.5	30.5	24.5	1.5	-6.5	-5.5	-7.5	-9.5	3.5
Participant Subgroup Overall Ranking	2	12	3	8	10	1	14	13	9	6	7	5	4	11

TABLE 11

ITMP NONPARTICIPANT SUBGROUP RANKINGS OF THE FOURTEEN CAPITAL INVESTMENT FACTORS

Nonparticipant Subcontractors	Capital Investment Factor Ranking													
	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	10	10	10	10	10	10	4	10	5	10	2	10	3	1
2	3	7	6	5	8	14	9	10	12.5	4	1	11	2	12.5
3	7	5	9	8	2	3	4	13	10	11	1	14	6	12
4	1	2	3	4	5	9	14	8	13	11	6	10	7	12
5	2.5	13.5	9.5	6.5	2.5	9.5	12	11	6.5	8	5	13.5	2.5	2.5
R_j	23.5	37.5	37.5	33.5	27.5	45.5	43	52	47	44	15	58.5	20.5	40
$R_j - \frac{\Sigma R_j}{N}$	-14	0	0	-4	-10	8	5.5	14.5	9.5	6.5	-22.5	21	-17	2.5
Nonparticipant Subgroup Overall Ranking	3	6.5	6.5	5	4	11	9	13	12	10	1	14	2	8

Note: All tied observations were assigned the average of the ranks if no ties had occurred (21:233).

TABLE 12

ITMP "CONSIDERATION" SUBGROUP RANKINGS OF THE FOURTEEN CAPITAL INVESTMENT FACTORS

"Consideration" Subcontractors	Capital Investment Factor Ranking													
	A	B	C	D	E	F	G	J	I	J	K	L	M	N
1	1	5	2	12	3	10	14	11	7	13	6	4	9	8
2	8	9	10	4	2	3	14	7	11	6	1	5	12	13
3	5	6	7	10	3	2	8	9	11	14	1	4	12	13
4	1	14	2	13	11	8	12	10	7	5	4	9	3	6
5	2	12	1	11	5	8	10	13	4	7	14	9	3	6
R_j	17	46	22	50	24	31	58	50	40	45	26	31	39	46
$R_j - \frac{\sum R_j}{N}$	-20.5	8.5	-15.5	12.5	-13.5	-6.5	20.5	12.5	2.5	7.5	-11.5	-6.5	1.5	8.5
"Consideration" Subgroup Overall Ranking	1	10.5	2	12.5	3	5.5	14	12.5	8	9	4	5.5	7	10.5

TABLE 13

ITMP "ORIENTED" SUBGROUP RANKINGS OF THE FOURTEEN CAPITAL INVESTMENT FACTORS

"Oriented" Subcontractors	Capital Investment Factor Ranking													
	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	8	13.5	8	3.5	3.5	3.5	11	11	13.5	3.5	11	3.5	3.5	8
2	4	3	5	1	2	12	13	14	10	7	8	11	6	9
3	10	9	12	3	2	4	8	14	7	13	1	6	11	5
4	8	9	7	3	5	1	14	13	11	10	2	6	4	12
5	5	11	6	4	8	2	13	10	12	9	1	7	3	14
R_j	35	45.5	38	14.5	20.5	22.5	59	62	53.5	42.5	23	33.5	27.5	48
$R_j - \frac{\Sigma R_j}{N}$	-2.5	8	.5	-23	-17	-15	21.5	24.5	16	5	-14.5	-4	-10	10.5
"Oriented" Subgroup Overall Ranking	7	10	8	1	2	3	13	14	12	9	4	6	5	11

Note: All tied observations were assigned the average of the ranks if no ties had occurred (21:233).

APPENDIX E

THE KENDALL COEFFICIENT OF CONCORDANCE TEST DATA FOR THE SAMPLE'S RANKING OF THE FOURTEEN CAPITAL INVESTMENT FACTORS

TABLE 14

SAMPLE'S RANKING OF THE FOURTEEN CAPITAL INVESTMENT FACTORS

ITMP Sub-groups	Column Totals (R_j) for Each Capital Investment Factor													
Partici-pant	22	48	26	37	40	21	68	62	39	31	32	30	28	41
Nonpar-ticipant	23.5	37.5	37.5	33.5	27.5	45.5	43	52	47	44	15	58.5	20.5	40
"Consid-eration"	17	46	22	50	24	31	58	50	40	45	26	31	39	46
"Ori-ented"	35	45.5	38	14.5	20.5	22.5	59	62	53.5	42.5	23	33.5	27.5	48
R_j	97.5	117	123.5	135	112	120	228	226	179.5	162.5	96	153	115	175
$R_j - \frac{\Sigma R_j}{N}$	-52.5	27	-26.5	-15	-38	-30	78	76	29.5	12.5	-54	3	-35	25
Sample's Overall Ranking	2	11	6	7	3	5	14	13	12	9	1	8	4	10
	A	B	C	D	E	F	G	H	I	J	K	L	M	N

Capital Investment Factor

TABLE 15

INDIVIDUAL SUBCONTRACTOR AND OVERALL SAMPLE RANKINGS OF THE FOURTEEN CAPITAL INVESTMENT FACTORS

Capital Investment Factor	Subcontractor/Subgroup										Overall Sample Ranking
	Participants					Nonparticipants					
	1	2	3	4	5	6	7	8	9	10	
Achieving a minimum ROI through shared savings	5	5	4	4	4	10	3	7	1	2.5	2
Government loans	12	7	5	11	13	10	7	5	2	13.5	11
Partial government funding	1	2	6	10	7	10	6	9	3	9.5	6
Interest as an allowable cost	8	8	8	3	10	10	5	8	4	6.5	7
Accelerated Depreciation	6	6	7	9	12	10	8	2	5	2.5	3
Multiyear contracts	2	1	1	6	11	10	14	3	9	9.5	5
Retraining workers with government funds	14	13	13	14	14	4	9	4	14	12	14
Reduced number of Tech Mod reports	13	14	14	13	8	10	10	13	8	11	13
Shared savings on all existing contracts	3	11	11	8	6	5	12.5	10	13	6.5	12

TABLE 15--Continued

Capital Investment Factor	Subcontractor/Subgroup: Participants 1	2	3	4	5	Nonparticipants 6	7	8	9	10	Overall Sample Ranking
Increased use of award fees	4	3	3	12	9	10	4	11	11	8	9
Providing a better quality product	7	9	10	1	5	12	1	1	6	5	1
Tech Mod in source selection	11	4	12	2	1	10	11	14	10	13.5	8
Government indemnification	9	10	2	5	2	3	2	6	7	2.5	4
Shared savings on all follow-on contracts	10	12	9	7	3	1	12.5	12	12	2.5	10

TABLE 15--Continued

Capital Investment Factor	Overall Sample Ranking	Subcontractor/Subgroup "Consideration" 11	12	13	14	15	"Oriented" 16	17	18	19	20
Achieving a minimum ROI through shared savings	2	1	8	5	1	2	8	4	10	8	5
Government loans	11	5	9	6	14	12	13.5	3	9	9	11
Partial government funding	6	2	10	7	2	1	8	5	12	7	6
Interest as an allowable cost	7	12	4	10	13	11	3.5	1	3	3	4
Accelerated Depreciation	3	3	2	3	11	5	3.5	2	2	5	8
Multiyear contracts	5	10	3	2	8	8	3.5	12	4	1	2
Retraining workers with government funds	14	14	14	8	12	10	11	13	8	14	13
Reduced number of Tech Mod reports	13	11	7	9	10	13	11	14	14	13	10
Shared savings on all existing contracts	12	7	11	11	7	4	13.5	10	7	11	12

TABLE 15--Continued

Capital Investment Factor	Overall Sample Ranking	Subcontractor/Subgroup									
		"Consideration"					"Oriented"				
		11	12	13	14	15	16	17	18	19	20
Increased use of award fees	9	13	6	14	5	7	3.5	7	13	10	9
Providing a better quality product	1	6	1	1	4	14	11	8	1	2	1
Tech Mod in source selection	8	4	5	4	9	9	3.5	11	6	6	7
Government indemnification	4	9	12	12	3	3	3.5	6	11	4	3
Shared savings on all follow-on contracts	10	8	13	13	6	6	8	9	5	12	14

APPENDIX F

THE FRIEDMAN TEST DATA FOR THE SAMPLE'S RANKING OF THE FOURTEEN CAPITAL INVESTMENT FACTORS

TABLE 16

ITMP SUBGROUPS' RANKINGS OF CAPITAL INVESTMENT FACTORS

ITMP Subgroup	Capital Investment Factor													
	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Participant	2	12	3	8	10	1	14	13	9	6	7	5	4	11
Nonparticipant	3	6.5	6.5	5	4	11	9	13	12	10	1	14	2	8
"Consideration"	1	10.5	2	12.5	3	5.5	14	12.5	8	9	4	5.5	7	10.5
"Oriented"	7	10	8	1	2	3	13	14	12	9	4	6	5	11
Column Sums, R_j	13	39	19.5	26.5	19	20.5	50	52.5	41	34	16	30.5	18	40.5

APPENDIX G

DATA ANALYSIS OF RESEARCH QUESTION NO. 1 FACTORS FOR THE FOUR ITMP SUBGROUPS

TABLE 17

ANALYSIS OF RESEARCH QUESTION NO. 1 FACTORS

Factor	Descriptive Statistic	ITMP Subgroup			
		Participant	Nonparticipant	"Consideration"	"Oriented"
Market Environment					
Number of Competitors (Sellers)	Mode				
Commercial		2-5	2-5	6-15	2-5
Air Force		2-5	2-5	1; 2-5	2-5
F-16		2-5	2-5	2-5	2-5
Number of Buyers	Median				
Commercial		24	52	19	8
DOD		18	12	8	20
Knowledge of Competition	Mode*				
Air Force		"uncertain"	"uncertain"	"uncertain"	"uncertain"
F-16		"uncertain"	"uncertain"	"uncertain"	"uncertain"
Cross Elasticity of Demand	Mode*				
USAF Product		"uncertain"	elastic	"uncertain"	"uncertain"
F-16 Product		"uncertain"	elastic	"uncertain"	"uncertain"
Freedom of Entry and/or Exit to DOD Marketplace	Mode*	free to enter and/or exit	not free to enter and/or exit	"uncertain"	"uncertain"

Note: Mode* was determined using the eighty-percent criterion test described in Chapter II.

TABLE 17--Continued

Factor	Descriptive Statistic	ITMP Subgroup			
		Participant	Nonparticipant	"Consideration"	"Oriented"
Perceived Market Environment	Mode				
Commercial		Oligopoly	Oligopoly	Perfectly competitive and duopoly	Perfectly competitive and oligopoly
Air Force		Oligopoly	Oligopoly	Perfectly competitive	Oligopoly
F-16		Oligopoly	Monopolistic competition	Perfectly competitive	Perfectly competitive
Percent DOD Business	Range (Mean)				
FY80					
DOD		40-50 (47.5)	24-97 (49.6)	2-93 (62.2)	47-98 (70.2)
F-16		3-5 (3.67)	0.6-15.0 (4.62)	1-47 (13.4)	4-15 (6.8)
FY81					
DOD		40-55 (48.75)	24-97 (52.0)	4-94 (63.4)	47-98 (70.2)
F-16		5-7 (6.0)	0.5-15.0 (4.8)	2-48 (16.6)	4-20 (8.0)
FY82					
DOD		45-65 (52.75)	24-97 (57.6)	4-96 (63.6)	47-98 (70.2)
F-16		3.6-10.0 (7.4)	0.3-15.0 (4.96)	1-48 (18.1)	4-20 (8.0)
Investment Financing Sources	Mode	"corporate pool"	"corporate pool"	"corporate pool"	"corporate pool," retained earnings, trade credit

TABLE 17--Continued

Factor	Descriptive Statistic	ITMP Subgroup			
		Participant	Nonparticipant	"Consideration"	"Oriented"
Capital Investment Decision Rules	Mode*	ROI; Payback Period	NPV; ROI; Payback Period	NPV; ROI; Payback period	ROI; Payback Period
Capital-Labor Mixture	Mode*	"uncertain"	"uncertain"	"uncertain"	"uncertain"
Age of Capital Equipment as Percent of Total Number of Items	Range(Mean)				
0-5 yrs		10-25(18)	10-50(27)	10-60(28)	15-55(39)
6-10 yrs		10-40(28)	0-50(16)	10-40(25)	10-65(31)
11-15 yrs		20-35(28)	0-35(18)	10-20(15)	5-15(10)
16-20 yrs		5-40(16)	0-30(15)	0-35(14)	0-20(11)
21-25 yrs		0-25(7)	0-15(4)	0-35(14)	0-20(4)
over 25 yrs		0-15(3)	0-53(21)	0-10(4)	0-25(5)
Average Age/Item of Capital Equipment		11.69 yrs	14.95 yrs	11.57 yrs	9.21 yrs
Labor Force Age (yrs)	Range(Mean)	35-43(37.6)	35-45(39.2)	35-51(39.0)	35-38(36.0)
Experience (yrs)	Range(Mean)	6-21(12.8)	6-22(13.4)	6.5-25(13.2)	4-12(7.4)

Note: Mode* was determined using the eighty-percent criterion test described in Chapter II.

TABLE 17--Continued

Factor	Descriptive Statistic	ITMP Subgroup			
		Participant	Nonparticipant	"Consideration"	"Oriented"
Need to Modernize	Mode*	"agree"	"agree"	"agree"	"agree"
Planning Period (Mos)	Mode	13-36	13-36; 37-60	13-36	13-36
Worker Adaptability to Automation	Mode*	"uncertain"	"agree"	"agree"	"agree"
Decision Criteria Policy	Mode	Corporate	Corporate	Company	Corporate
Capital Investment External Approval Required	Mode	Yes	Yes	Yes	Yes
Maximum Capital Investment without External Approval	Mode	$1	$50,000	$50,000	$100,000

Note: Mode* was determined using the eighty-percent criterion test described in Chapter II.

APPENDIX H

CHI-SQUARE TEST FOR THE AGE DISTRIBUTION OF CAPITAL EQUIPMENT

The chi-square (χ^2) test for two independent samples permitted the researchers to determine the significance of the difference between the age distribution of capital equipment for the ITMP participant and nonparticipant subgroups. The χ^2 test was an appropriate nonparametric statistical test for determining the difference with respect to the capital equipment age factor, since the research data were at least nominal and consisted of frequencies in discrete categories (21:104). The hypotheses, procedures and results of the χ^2 test were:

1. Null Hypothesis (H_0). There was no difference between the age distribution of capital equipment of the participant and nonparticipant subgroups. H_a: There was a difference in the percentage of items of capital equipment appearing in the age categories for the two subgroups.

2. Significance Level. The .05 significance level was established as previously discussed in Chapter II.

3. Statistical Test. The χ^2 test was selected because the two subgroups were independent, and the data under investigation were frequencies in discrete categories.

4. Decision Criteria. The χ^2 computed value had a sampling distribution approximated by the chi-square distribution with degrees of freedom (df) = 5; therefore, if the χ^2 computed value $\geq$ χ^2 critical value obtained from

a chi-square distribution table at .05 significance level, df = 5 for a two-tailed test, then H_0 was rejected.

5. χ^2 Test Result. χ^2 computed (20.66) $\geq \chi^2$ critical (11.07) resulted in the rejection of H_0, meaning significant differences existed between the participant and nonparticipant subgroups' age distribution of capital equipment.

6. χ^2 Test Computations. The data and χ^2 test calculations are presented in the following pages.

TABLE 18

DATA FOR CHI-SQUARE TEST

Age of Capital Equipment	ITMP Subgroup				Observed Total
	Participant		Nonparticipant		
	Observed	Expected	Observed	Expected	
0-5 yrs	18	22.5	27	22.5	45
6-10 yrs	28	22	16	22	44
11-15 yrs	28	23	18	23	46
16-20 yrs	16	15.5	15	15.5	31
21-25 yrs	7	5.5	4	5.5	11
Over 25 yrs	3	11.5	20	11.5	23
Total	100		100		200

$$\chi^2 = \sum_{i=1}^{r} \sum_{j=1}^{k} \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$

where O_{ij} = the observed number of cases categorized in ith row of the jth column,

E_{ij} = number of cases expected under H_0 to be categorized in the ith row of the jth column,

r = number of age categories (rows), and

k = number of subgroups (columns).

Computed chi-square (χ^2) = 20.661617

Degrees of Freedom (df) = (k-1)(r-1)
(df) = (2-1)(6-1)
(df) = 5

Level of Significance = .05

Critical $\chi^2_{5,.05}$ = 11.07

The previously described χ^2 test was repeated excluding the "over 25 years" age category data. The null hypothesis (H_0), alternate hypothesis (H_a) and significance level (.05) were identical to those used in the first χ^2 test. The exclusion of the "over 25 years" reduced the number of rows (r) to 5 and the degrees of freedom to 4. The decision criteria remained if the χ^2 computed value $\geq \chi^2$ critical value obtained from the chi-square distribution table, for $\alpha = .05$ and df = 4 for a two-tailed test, then H_0 was rejected. The χ^2 computed (excluding the "over 25 years" category) was 6.512 which was less than the obtained χ^2 critical value of 9.49; therefore, H_0 could not be rejected. The interpretation of the test results was that, when the "over 25 years old" age category was excluded, the χ^2 test provided insufficient evidence for the researchers to conclude that the participant and nonparticipant subgroups differed with respect to the age distribution of their respective capital equipment.

The data and χ^2 test calculations are presented on the following page.

TABLE 19

DATA FOR CHI-SQUARE TEST NOT USING OVER 25 YEARS CATEGORY

Age of Capital Equipment	ITMP Subgroup				Observed Total
	Participant		Nonparticipant		
	Observed	Expected	Observed	Expected	
0-5 yrs	18	24.66	27	20.34	45
6-10 yrs	28	24.11	16	19.89	44
11-15 yrs	28	25.21	18	20.79	46
16-20 yrs	16	16.99	15	14.01	31
21-25 yrs	7	6.03	4	4.97	11
Total	97		80		177

Computed $\chi^2 = 6.512$

Degrees of Freedom (df) = 4 $\alpha = .05$

Critical $\chi^2_{4,.05} = 9.49$

APPENDIX I

MANN-WHITNEY U TEST FOR THE AVERAGE AGE OF CAPITAL EQUIPMENT

The researchers used the Mann-Whitney U test to determine whether a difference existed between the average age of an item of capital equipment in the participant and nonparticipant subgroups. The Mann-Whitney U test provided a "powerful" nonparametric counterpart to the parametric t test that could be applied on data that were at least ordinal and in a research situation where weaker statistical assumptions regarding the two populations were present (21:117). The hypotheses, procedures, and results of the Mann-Whitney U test were:

1. Null Hypothesis (H_0). There was no significant difference between the average age of an item of capital equipment in the participant and nonparticipant subgroups. H_a: There was a difference between the average age of a piece of capital equipment in the two subgroups.

2. Significance Level. The .05 significance level was established as previously discussed in Chapter II.

3. Mann-Whitney Test. The researchers computed a weighted average age per item of capital equipment for each subcontractor in each of the two subgroups. The average ages were arranged in increasing order, and a U value was computed by counting the number of times an average age from a nonparticipant subcontractor preceded an average age from a participant subcontractor.

4. Decision Criteria. Using a Mann-Whitney Probability Table for the computed U value with $n_1 = n_2 = 5$, ($n_1 = n_2$ = number of subcontractors in each subgroup) if the tabulated probability $\leq$ the .05 significance level, then H_0 was rejected.

5. Mann-Whitney Test Results. For a computed U value = 9, the associated two-tailed probability was .548; thus, there was insufficient evidence to reject H_0, meaning the data did not support the hypothesis that the average age of an item of capital equipment for the participant subgroup differed significantly from that of the nonparticipant subgroup.

6. Mann-Whitney Calculations. The data and calculations of the U value are presented on the following page.

TABLE 20

DATA FOR MANN-WHITNEY U TEST

Weighted Average Age/Item (yrs)	ITMP Subgroup
8.475	NP[a]
9.150	P[b]
9.900	P
10.045	P
11.295	NP
11.650	NP
12.950	P
15.975	P
16.165	NP
20.000	NP

Notes: [a]NP = ITMP nonparticipant subgroup subcontractor.

[b]P = ITMP participant subgroup subcontractor.

Calculation of Mann-Whitney U value:

$$U = 1 + 1 + 1 + 3 + 3 = 9.$$

APPENDIX J

KRUSKAL-WALLIS TEST FOR THE AVERAGE AGE OF CAPITAL EQUIPMENT

The Kruskal-Wallis test enabled the researchers to determine if the four ITMP subgroups came from identical populations with respect to the average age per piece of capital equipment (21:184). The researchers assumed that the age of capital equipment had an underlying continuous distribution and acknowledged that the age of capital equipment factor's measurement level was at least ordinal (21:185). The Kruskal-Wallis hypotheses, procedures, and results were:

1. Null Hypothesis (H_0). There were no differences in the average ages of pieces of capital equipment among all four subgroups. H_a: The average ages from the four subgroups were not the same.

2. Significance Level. The .05 significance level was established as previously discussed in Chapter II.

3. Kruskal-Wallis Test. The researchers computed a weighted average age per piece of capital equipment for each of the five subcontractors in each of the four subgroups. The average ages were ranked from the lowest to the highest, and a H value was calculated using the sum of the column ranks (R_j) for each of the subgroups.

4. Decision Criteria. Since the number of subgroups exceeded three, the chi-square distribution was used to approximate the sampling distribution of H (21:185). If

the computed value of H was $\geq$ to the tabulated chi-square value for degrees of freedom (df) = 3 and a .05 significance level, then H_0 was rejected.

5. Kruskal-Wallis Test Results. Since the calculated H value (3.20) $\leq$ the tabulated χ^2 value (7.82), the decision was that there was insufficient evidence to reject H_0, meaning the data did not support the hypothesis that the average ages of an item of capital equipment among the four subgroups significantly differed.

6. Kruskal-Wallis Calculations. The data and calculations follow on subsequent pages in the appendix.

TABLE 21

WEIGHTED AVERAGE AGE OF A SUBCONTRACTOR'S ITEM OF CAPITAL EQUIPMENT BY ITMP SUBGROUP (In Years)

ITMP Subgroup			
Participant	Nonparticipant	"Consideration"	"Oriented"
15.975	20.000	5.200	5.975
9.900	11.295	14.300	6.690
12.950	8.475	10.830	21.175
10.045	11.650	16.700	7.125
9.150	16.165	11.175	7.750

TABLE 22

WEIGHTED AVERAGE RANK OF A SUBCONTRACTOR'S ITEM OF CAPITAL EQUIPMENT BY ITMP SUBGROUP

ITMP Subgroup			
Participant	Nonparticipant	"Consideration"	"Oriented"
16	19	1	2
8	12	15	3
14	6	10	20
9	13	18	4
7	17	11	5
$R_1 = 54$	$R_2 = 67$	$R_3 = 55$	$R_4 = 34$

$$H = \frac{12}{N(N+1)} \sum_{j=1}^{k} \frac{R_j^2}{n_j} - 3(N+1)$$

where k = number of ITMP subgroups;

n_j = number of cases in jth sample;

$N = \Sigma n_j$, the number of cases in all samples combined; and

R_j = sum of ranks in jth sample (column).

Computed H = 3.205715

Degrees of Freedom (df) = k-1

$df = 3; \alpha = .05$

Critical $\chi^2_{3,.05} = 7.82$

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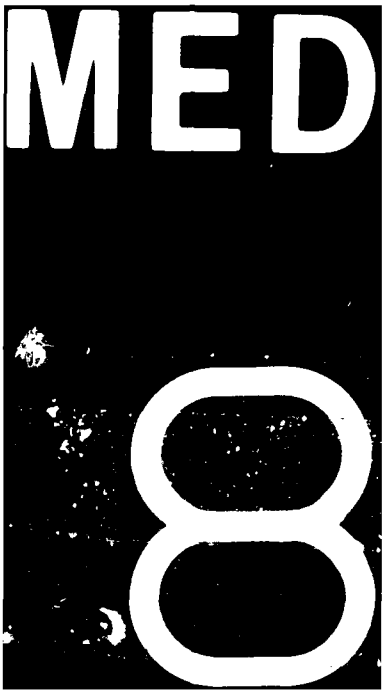
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